POWER PLANT ENGINEERING

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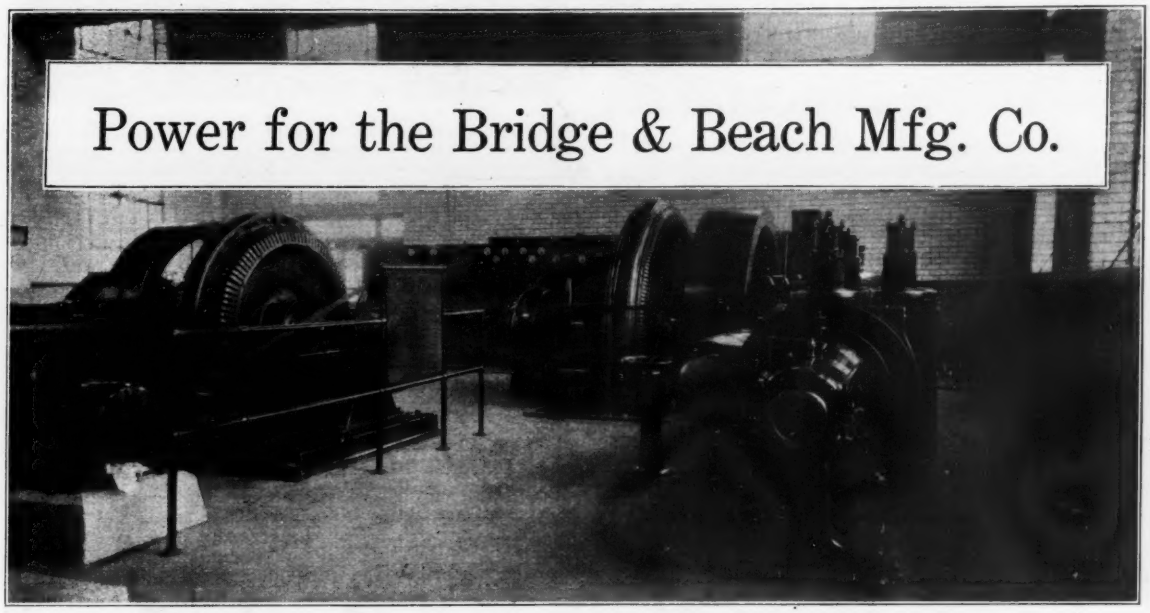


NEW POWER PLANT OF ST. LOUIS' OLDEST STOVE MANUFACTURING PLANT IS A FINE EXAMPLE OF SMALL POWER PLANT CONSTRUCTION

ONE OF THE MOST conspicuous features of the new power plant of the Bridge and Beach Mfg. Co. at St. Louis, Mo., is its simplicity. It is free from all undue complexity and its construction denotes a high standard of engineering.

Perhaps the fact that this company has been in business since 1837 and is the oldest corporation in the state of Missouri accounts for the common sense displayed in the construction of the plant. It takes experience to convince us of the fact that the best solution to a problem is the one which is least complicated and it is probable that during the company's eighty-seven years of existence this fact has been fully brought home to them in more ways than one. It is natural, therefore, that when the plans and specifications for a new power plant were drawn up, a considerable amount of common sense was introduced between the lines.

This power plant furnishes power, light and heat to the group of factory buildings which make up the Bridge and Beach Mfg. Co. The building is a one story brick structure with basement and is centrally located with respect to the factory group. Steam, water and electricity are distributed to the factory buildings underground. Alternating current is generated at 440 v. and is transmitted at that voltage to the motors in the plant. Current for lighting purposes is stepped down to 110 v. at the various points of consumption.

Heat for the factory buildings is supplied by exhaust steam from the engines, although provision is made for the bypassing of live steam to the heating system in case of necessity.

GENERAL FEATURES

Steam is generated in three O'Brien, Heine type, boilers rated at 250 hp. equipped with Laclede-Christy chain grate stokers. These stokers are driven from eccentrics on a line shaft which extends across the boiler fronts, and which is driven at one end by an Engberg, high speed, vertical engine.

Electric power is generated by two 440-v., 3-phase alternating current generators, one of which is rated 300 kw. and the other at 96 kw. The former is direct connected to a Chuse poppet valve uniflow engine while the latter is driven by a Chuse non-releasing Corliss engine. Both engines operate non-condensing against a back pressure which never exceeds 2 lb.

FEATURES REGARDING FUEL HANDLING

Coal is delivered to the plant direct by railroad cars and is dumped into bins in front of the boilers. From these coal bins, the fuel is shoveled into the stoker hoppers by hand. At the time that this plant was constructed it was the intention of the engineering department to install overhead coal bunkers and a coal handling system. The

appropriation for the construction of the plant, however, fell short of what had at first been proposed and as a consequence the installation of the overhead coal bunkers has been postponed. The constructional features of the present plant, however, are such that the addition of the coal bunkers and associated coal handling machinery will involve a minimum of alteration expense.

A diagram of the Jeffrey ash handling apparatus is shown in Fig. 7. This may also be seen in the photograph of the boiler room, Fig. 3.

Ash is removed from the ash pits in the basement beneath the firing aisle, and is delivered to the feed hopper of the ash elevator by means of small hand cars. The bucket elevator raises it to the top of the boiler room from which it flows by gravity into cars or trucks on the outside of the building.

noted, fluctuates widely and at no time during the 24 hr. did it remain constant for any length of time. Chart B shows the variations in pressure with the regulator in action. There it will be seen, the regulator came into action shortly after six o'clock in the morning and remained on the line until the plant shut down for the night at 4 p. m. During the entire time the regulator was in action, the pressure did not vary over 10 lb. and for the greater part of the time it maintained the steam pressure constant within four pounds. During the night time when the regulator was off, the pressure fluctuated widely.

Details of the boilers and setting are shown in Fig. 4. These boilers are fitted with two rows of horizontal baffling and are equipped with Bayer soot blowers. Stets feed water regulators and Reliance safety water columns are provided. Draft is measured by Defender draft gages and

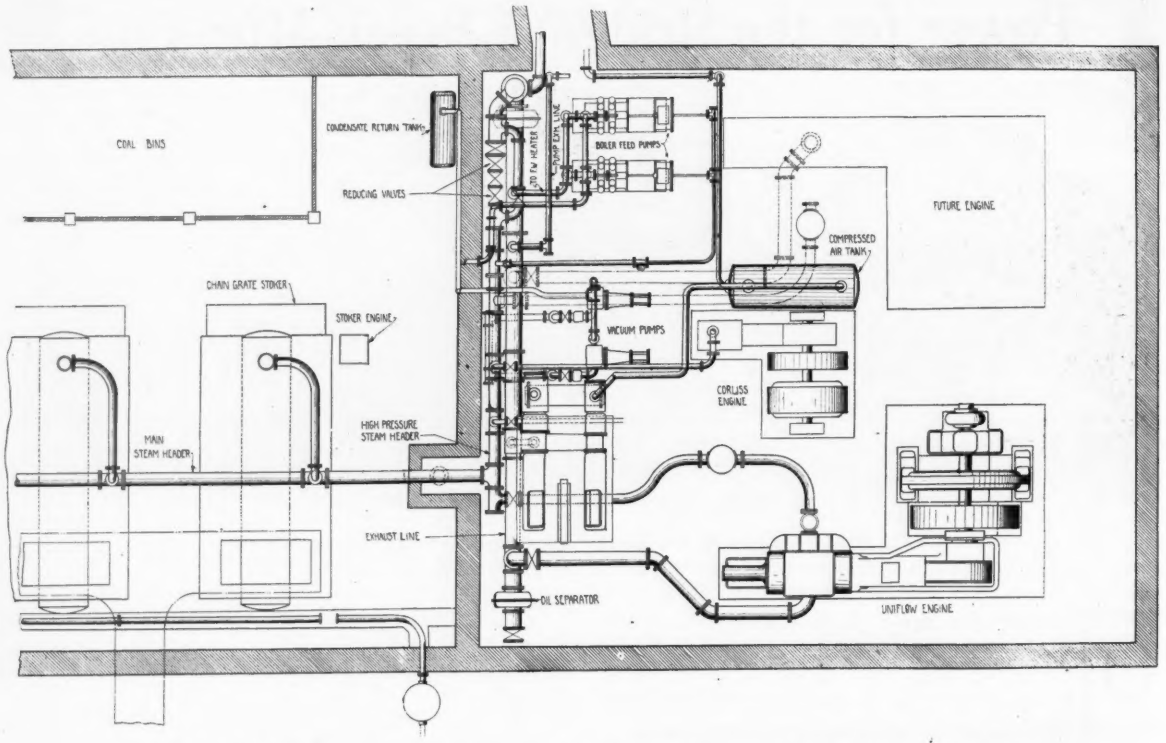


FIG. 1. GENERAL PIPING ARRANGEMENT OF ENGINE ROOM BASEMENT AND BOILER ROOM

Boiler Equipment

Boiler equipment, as stated previously, consists of three 250-hp., O'Brien water-tube boilers. The stokers are set in Dutch oven type furnaces which have given a high degree of satisfaction. Steam is generated at a pressure of 150 lb.

Draft and stoker speed is controlled by means of a Defender Automatic damper regulator. This regulator is controlled directly by the steam pressure in the boiler and has proved extremely effective in maintaining a constant pressure. If the steam pressure for any reason should tend to rise, the regulator comes into action, immediately closing the damper and at the same time reduces the speed of the stoker engine. If the pressure falls, the opposite action takes place and the stoker speed is increased. The effect of this device is apparent from the charts shown in Fig. 8. Chart A is a record of the steam pressure on a day when the regulator was not in use. The pressure, as may be

a Defender pyrometer is installed to measure the temperature of the gases in the last pass in the boilers. This, as a rule, is about 450 to 480 deg. The boilers are fitted with Homestead blowoff valves.

For determining the composition of the flue gases, a Defender CO_2 indicator has been installed.

Steam Piping

Steam is taken from the boilers by individual headers which connect into a main header which is installed above the boilers and which passes downward to the engine room basement at one end of the room.

In the engine room basement, steam is distributed to the engines, pumps and air compressor in the manner indicated in Fig. 1. Here, it will be noted, the main steam line is installed against the basement wall; parallel to the main exhaust line. At one end, the main steam line connects into the exhaust or heating line through two Fisher

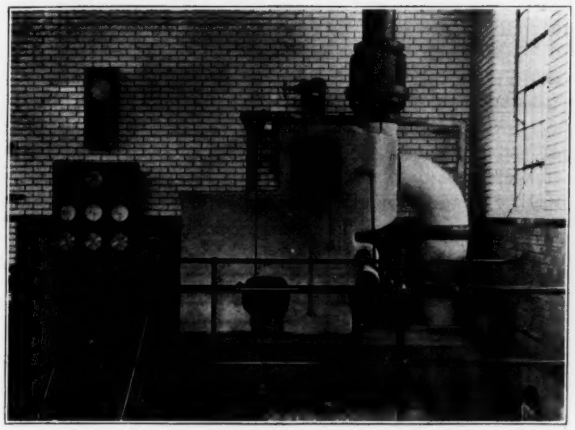


FIG. 2. FEED WATER HEATER AND GAGE BOARD INSTALLED IN ENGINE ROOM

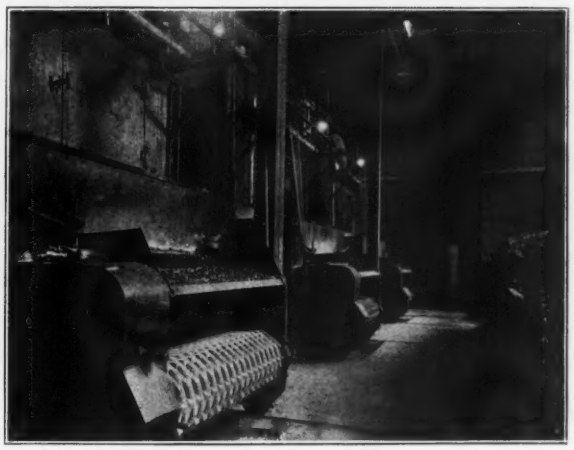


FIG. 3. VIEW OF THE FIRING AISLE SHOWING ASH HANDLING EQUIPMENT AT REAR

reducing valves, the first one reducing the pressure from 150 to 50 lb. and the second one reducing from 50 to about 2 lb. Live steam is also taken from the main steam line and reduced to a pressure of 75 lb. for process work in the nickel plating department.

Heating Returns and Boiler Feed Water

All returns from the heating system are pumped by either of two Warren Webster vacuum pumps into a tank located in the boiler room. Water from this tank together with such makeup as necessary is then delivered by the boiler feed pumps to a H. S. B. W.-Cochrane Corp. open type feed water heater. This heater is installed in the engine room as shown in Fig. 2. The boiler feed pumps are Epping-Carpenter duplex pumps controlled by Fisher governors.

An oil separator is connected at each end of the main exhaust line just ahead of the point where the low pressure steam passes to the heating system. These are provided to insure freedom from oil in the heating returns and to prevent trouble due to accumulations of oil on the heating surfaces of the radiators.

Features of the Engine Room

Figure 6 and the headpiece will serve to give the reader a general idea of the appearance of the engine room. This room is exceptionally well designed and presents an attractive appearance. The walls are of white glazed brick with a cream colored wainscoting extending around the entire room to a height of four feet. All windows are of wired glass set in modern steel sash. The floors and foundations of the building are of reinforced concrete with plain smooth finish.

Engines, generators and the air compressor are painted an olive green and the magnesia pipe covering on all visible piping is held in place with polished brass bands.

The roof is flat, slightly sloping, of reinforced concrete and is supported by steel trusses. A large skylight in the center of the ceiling provides ample natural illumination.

At this plant the personal comfort of the employes has evidently been given considerable attention. As an illustration, we may call attention to the large slow speed fan installed immediately above the chief engineer's desk. Other features are the large wash rooms with shower bath

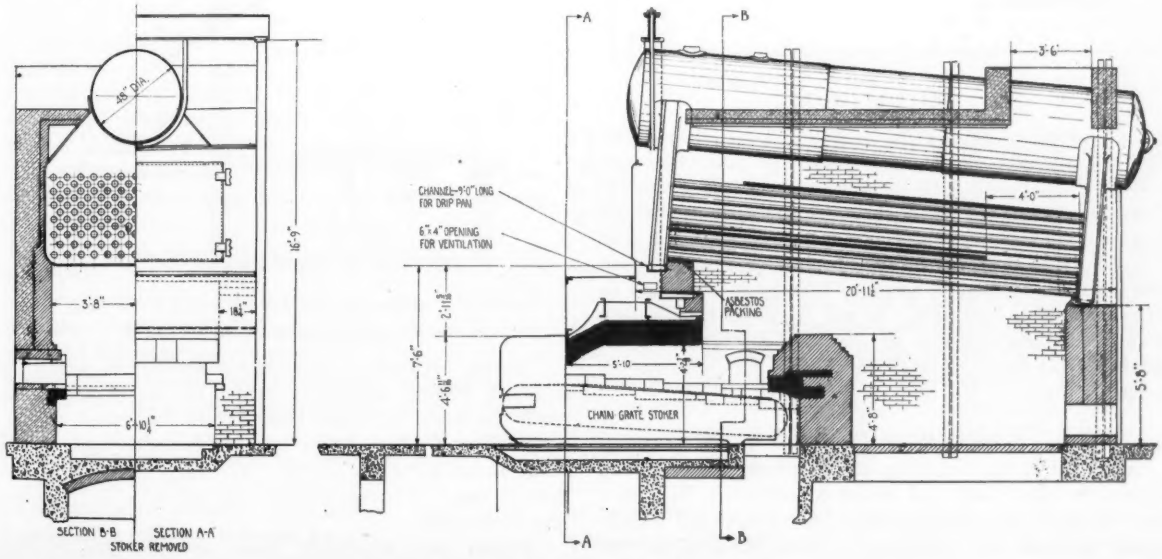


FIG. 4. DETAILS OF THE BOILERS

facilities, and a separate locker room for the safekeeping of the employes' clothes.

This feature of comfort to the employes and plant appearance must not be overlooked, nor considered as being apart from the power plant problems as a whole, for, in an indirect way, they contribute greatly to the efficient operation of the plant.

In large stations, public service plants, etc., all the necessities in the way of personal comfort are, as a rule, provided and it is for this reason that it is not difficult to maintain a high morale among the operatives. The same is true with regard to arrangement and plant appearance.

It is human nature to neglect something that already has been neglected and if a piece of equipment is installed

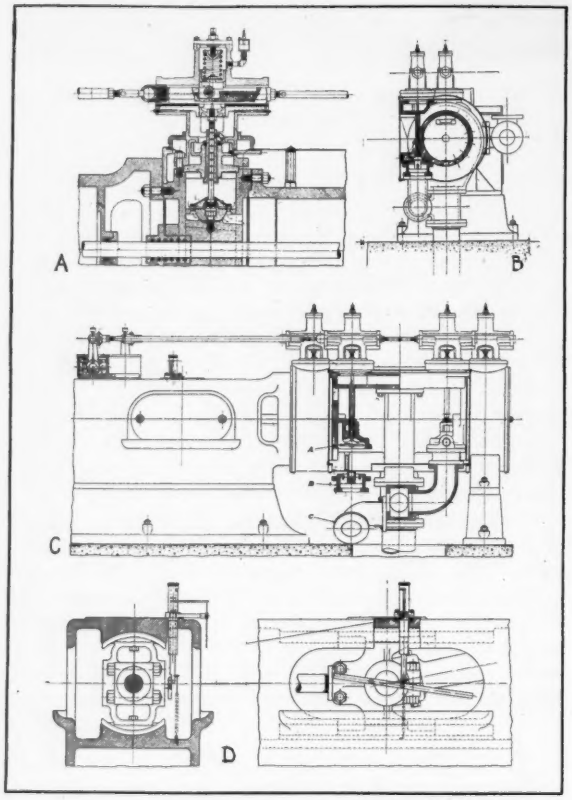


FIG. 5. DETAILS OF ENGINE MECHANISM

in such a manner as to make its maintenance and adjustment difficult, it is likely not to receive as much attention as it would if it had been installed in an easily accessible place. If the apparatus is installed so as to present an attractive appearance, if it is accessible and placed so that it may be kept clean easily, the operator or attendant will take a certain amount of pride in keeping it clean and in perfect operating condition. It will eliminate the "What's the use" attitude which we so often find displayed. Neatness is a great factor in bringing about a high efficiency in the small plant.

Engine Room Equipment

As stated in the beginning of this article, there are two engines installed, each one direct connected to its generator. A 10-17 by 15-9½ by 12-in. cross compound Worthington Laidlaw air compressor is also installed in the engine room. The large engine is a Chuse 23 by 28-in. non-condensing, uniflow engine with tail rod, operating normally at 150 r.p.m.

This engine is fitted with auxiliary exhaust valves, located at the side of the cylinder, at the end of the stroke. These exhaust valves are operated by the same type of cam and slide mechanism as the steam valves, except that they are driven by a fixed eccentric instead of the governor.

FIG. 6. AMPLE SPACE BETWEEN APPARATUS INSURES PROPER CARE

The function of these auxiliary exhaust valves must not be confused with the usual type of exhaust valves, as they only serve to release a small portion of the steam from the cylinder at a time when the pressure is practically zero. The main volume of the expanded steam is exhausted through the central exhaust ports, which are uncovered by the piston at nine-tenths of its stroke, the purpose of the auxiliary valves being merely to delay the compression to such a point that the pressure in the cylinder at the end of the compression stroke will be approximately 80 per cent of the initial pressure.

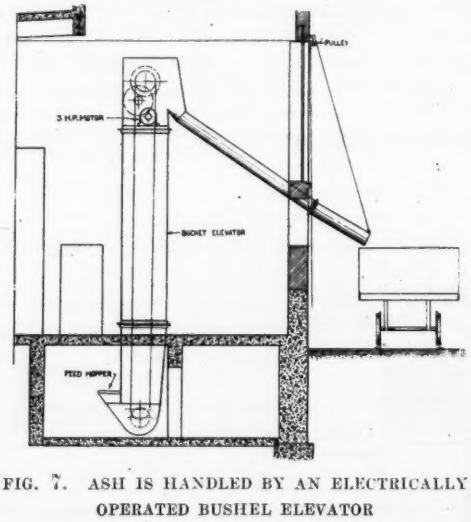


FIG. 7. ASH IS HANDLED BY AN ELECTRICALLY OPERATED BUSHEL ELEVATOR

Figures 5B and C illustrate the manner in which the auxiliary exhaust valves are located on the cylinder. To reach the valve it is only necessary to disconnect the exhaust elbow C, Fig. 5, leaving one bolt for a pivot and swing it down out of the way. The valve chamber B may then be removed without disturbing the valve A or its setting in any way.

Poppet type admission valves are provided on this engine, Fig. 5A showing a complete assembly of the cam-

head, roller slide, valve and valve stem. The roller slide is operated by means of a rocker arm driven by the governor eccentric. The roller slides under the cam and lifts the small crosshead which carries the valve stem and valve. The construction of the cam is such that it gives the maximum valve opening with a small travel of the roller.

Another feature of interest regarding this engine is the permanently attached type of indicator reducing motion shown in Fig. 5D. An inclined rail is bolted to the crosshead and acts as a cam to raise and lower the roller and stem to which the cord is attached. This reducing motion is ready for use at any time by simply turning the upper sleeve, which acts as a lock to hold the stem and cord out of operation when not in use.

Both generating units have individual exciters. In the case of the large unit, the exciter is direct connected to the main shaft while on the small unit, the exciter is belt driven from a pulley mounted on the outboard side of the generator bearing. The small engine is a 14 by 17-in. Chuse non-releasing Corliss engine operating at 225 r.p.m. and connected to a 96-kw., 440-v., 3-phase General Electric Co. generator.

Foundations are provided for a third generator unit should future power requirements exceed the capacity of the present installed units. The steam and exhaust piping was also installed with the future unit in view. Suitable fittings are provided in these lines so that when the future unit is installed it will be merely necessary to remove the blank flanges from these fittings and connect up the new engine piping.

In the corner of the engine room adjacent to the feed water heater, there is installed a gage board on which are mounted the following instruments:

1 Recording pressure gage showing steam pressure.
1 Recording thermometer showing feed water temperature.
1 Recording vacuum gage for heating system.
1 Indicating steam pressure gage.
1 Indicating air pressure gage, and
1 Indicating exhaust pressure gage.

These instruments are all of Foxboro manufacture.

Electricity generated is controlled and distributed from a 14-panel switchboard of General Electric design and construction throughout. This board is a two section, vertical board; of marine finish black slate and consists of a regulator panel, 1 blank exciter panel, 1 equipped exciter panel, 1 blank generator panel, 2 equipped generator panels, 1 totalizing panel and 7 feeder panels. The voltmeter and synchroscope is mounted on a swinging bracket at one end of the board.

This plant has been in operation a little over 2 yr. and during that time has given excellent satisfaction. Records are kept of the amount of water evaporated, the amount of coal burned, the electrical output and the amount of exhaust and live steam supplied to the factory. The average evaporation is about 8 lb. of water per lb. of coal.

In concluding this article, we wish to extend credit to L. D. Bridge, Superintendent of the Bridge and Beach Mfg. Co. and to Emmett R. Cooke, chief engineer of the power plant, for courtesies extended during the preparation of this article.

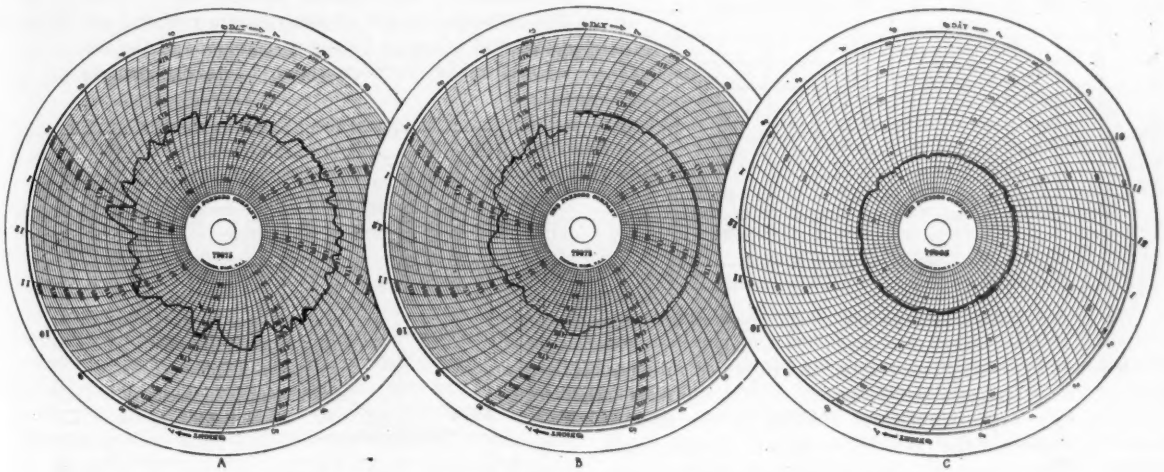


FIG. 8. TYPICAL CHARTS, SHOWING STEAM PRESSURE AND VACUUM

A. Record of steam pressure with damper regulator out of service
B. Steam pressure with regulator in service
C. Record showing the variation in vacuum on the heating system

Use and Abuse of Iodine in Accidents

TINCTURE of iodine, says the statement of the Conference Board of Physicians in Industry, should be used only in and around the wound. It should be applied within 8 hr. after injury occurs—the sooner the better.

Every skin, no matter how clean it may appear, has thousands of germs on its surface ready to poison a fresh wound before Nature can build a defense against them. If iodine is applied immediately, or a short time following the injury, these germs are destroyed before they have a chance to infect the wound. If application of iodine is delayed beyond 8 hr., the germs will have grown into the wound so deeply that the iodine will not reach them.

One thorough application of iodine is enough, as it has no healing properties. It should not be applied too strong, as sometimes occurs when the solution has been made stronger by leaving the cork out of the bottle and allowing the contents to evaporate.

Improving a Chain Grate Boiler Furnace

SYSTEMATIC INVESTIGATION OF GAS COMPOSITION, DESCRIBED RECENTLY BEFORE THE METROPOLITAN SECTION OF THE A. S. M. E., WHICH LED TO IMPROVED FURNACE DESIGN FOR BURNING SMALL SIZES OF ANTHRACITE. BY A. R. MUMFORD*

FOR these investigations, the boiler used was a four-drum Edge Moor water-tube boiler, 29 and 30 tubes wide and 16 tubes high, containing 10,000 sq. ft. of heating surface. The gases crossed the tubes three times in their path through the boiler which was baffled by the ordinary Edge Moor type baffles.

In all figures a section through the center line of one of the stokers is shown as a background. Beneath the grate are four separate air-chambers to which air is supplied through three wind-boxes from a main air duct. In this paper the grates are considered to be divided into four sections, one over each air-chamber. Each wind-box is equipped with slide dampers to control the air pressure under the section of the grate above the corresponding air-chamber. The fourth air-chamber is divided by two vertical partitions into three compartments, each controlled by a damper, so that if a hole appears in the fuel bed, the damper to the lateral compartment under the hole can be closed to prevent too great an amount of air from entering the furnace.

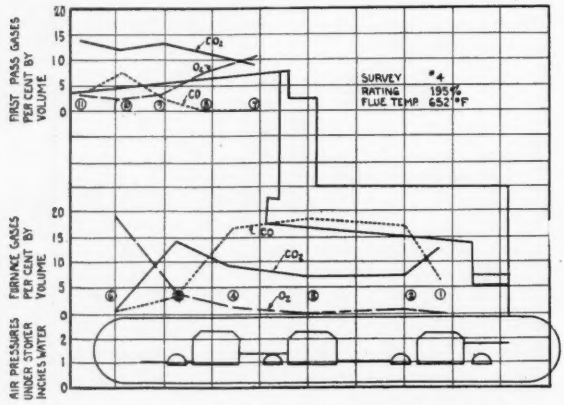

FIRST PASS GASES PER CENT BY VOLUME
FURNACE GASES PER CENT BY VOLUME
AIR PRESSURES UNDER STOKER INCHES WATER
SURVEY #4
RATING 195%
FLUE TEMP 652°F

FIG. 1. NORMAL OPERATION WITH LOW ARCH

Two chain grate stokers are placed side by side under each boiler and operated by means of separate controls. A center wall separates the stokers and extends to within two-thirds of the distance from the front of the furnace to the bridgewall. This center wall is racked back from the bottom, near the bridgewall, to a curtain wall at the front. The curtain wall extends from the top of the front arch to the bottom of the front water leg. The front arch is a sprung arch and is 10 ft. long extending from the ignition arch to about 8 ft. from the bridgewall. The bridgewall rises vertically from the floor level to the boiler tubes and is joined to the first baffle. Coal is fed to each stoker through separate chutes and the initial thickness of the fuel bed is controlled by the ordinary coal gates.

In order to learn how the mixing action of the furnace might be improved and to outline accurately the path of the gases through the furnace, simultaneous samples of the gases in the furnace were collected at 11 points. Six of these points were on a horizontal line about 6 in. above the fuel bed and five on a horizontal line just below the boiler tubes. The flue gases were sampled simultaneously by means of a special sampling tube which drew gas from the whole width of the uptake. The temperature of the flue gases was measured by copper-constantan thermocouples inserted in the openings between the drums just below the uptake. In order to eliminate any error from momentary changes in the fuel bed, the gas samples were collected over a period of 20 min. During this interval, the flue gas temperatures and the air pressures under the stoker were noted every 5 min.

Results of some of the studies of the furnace gases are plotted on the charts, Figs. 1 to 7 inclusive. The holes through which the sampling tubes were inserted into the furnace are indicated by small circles enclosing identifying numbers. In some diagrams, for the purposes of ready comparison, two sets of analyses are reported on the same chart and a heavier line is used for one of the sets in order to distinguish between them. The background of each chart is an outline drawing of the furnace and stoker as it existed during the study shown.

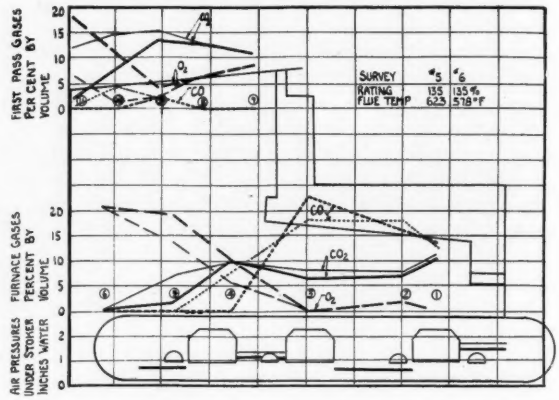

FIRST PASS GASES PER CENT BY VOLUME
FURNACE GASES PERCENT BY VOLUME
AIR PRESSURES UNDER STOKER INCHES WATER
SURVEY #5 #6
RATING 135 135%
FLUE TEMP 623 518°F

FIG. 2. EFFECT OF INCREASING AIR PRESSURE IN LAST AIR CHAMBER

STUDIES OF COMBUSTION UNDER NORMAL OPERATING CONDITIONS

In Fig. 1 is shown the composition of the furnace gases under normal operating conditions. A study of the curves in Fig. 1 shows that immediately over the fuel bed at the front half of the furnace, there is little or no oxygen present and considerable combustible gas. At the rear of the furnace considerable oxygen is present and little or no combustible gas. In the first pass more oxygen is present near the curtain wall than near the bridgewall and conversely no combustible gas is present near the curtain wall although a rather large amount is present near the bridgewall.

An analysis of these curves leads to the conclusion that free oxygen is present at the very front and at the rear while in between a large amount of combustible gas is present. In order to burn the coal completely in the furnace these three streams of gas must be mixed.

* Fuel Engineer, New York Steam Corporation.

Evidently the gaseous products of combustion acquire considerable velocity as they pass under the front arch because the gas stream could be seen to pass toward the rear of the furnace beyond the end of the main arch before turning to enter the boiler. The stream actually impinged on the bridgewall and its direction was changed by this wall and the stack draft toward the heating surface of the boiler. The presence of the main gas stream nearer the bridgewall than the curtain wall is confirmed by the analyses of the gases entering the boiler and by pitot-tube measurements, which indicated that the velocity at points 9, 10 and 11 was 4 to 6 times that at points 7 and 8.

Effects of Increasing the Grate Speed on Ignition

It was found that combustion at point 1 is more complete when the grate travels faster and this points to the fact that more air enters the furnace at the front. An increase in air entering at the front of the furnace can only take place through green coal and if the thickness of the fuel bed and the pressure of air in the first air-chamber are the same then there must be a larger area of green coal exposed to the pressure in the first air-chamber at higher grate speeds to account for the more complete combustion at point 1. In other words, as the grate travels faster ignition takes place later.

Effect of Increasing the Air Pressure in the Last Air-Chamber

In order to study the effect of adding more air by increasing the pressure in the last air-chamber, a set of samples was collected with no change other than the increase in pressure mentioned. The results are given in Fig. 2. The light lines indicate normal operation and the heavy lines indicate the effect of the additional air introduced through the refuse at the end of the stoker.

Results show that immediately above the fuel bed the gas composition did not change appreciably at the front of the furnace, but at the rear the oxygen is much higher with the higher pressure. At the entrance to the first pass, the effect of the increased air supply is evident. The gas composition at points 7 and 8 is essentially the same for both trials. At point 9 there is evidence of a slight effect of the additional air while at points 10 and 11 the rapid fall of the CO_2 curve and the rise of the O_2 curve show that the additional air affected the gases passing these points materially. It is true the CO was reduced but the reduction in CO_2 and increase in O_2 showed the method to be impractical.

Effect of Raising the Main Arch on Combustion in the Furnace

In an attempt to reduce the loss from particles of solid combustible blown from the front of the grate and carried to the ashpit, the main arch was raised to the extent shown as a background in Fig. 3. The arch was raised 1 ft. at the front and 2 ft. at the rear thus increasing the cross-sectional area at the rear by about 16 sq. ft. and by about 8 sq. ft. at the front.

Preliminary observations made on a boiler whose arch had been raised, indicated that the quantity of particles of solid combustible dropping from the gases to the ashpit was decreased but the decrease was not as great as might be expected. The preliminary observations from the standpoint of gaseous combustion were more definite. The actual stream of gas could be observed to rise immediately at the end of the front arch and not to continue to the bridgewall as was the case with the low arch. Thus it was concluded that the reduction in horizontal gas velocity under the front arch was sufficient to reduce the loss from particles of solid combustible somewhat but its greatest effect was to change the point at which the main gas stream entered the boiler from next the bridgewall with a low arch to near the curtain wall with a high arch.

Actual surveys of the effect on combustion of raising the front arch completely confirm the preliminary observations given above. The composition of the gases over the fuel bed and entering the boiler are shown by the heavy lines in Fig. 3. In this figure the background shows the two heights of arches. The light weight lines show the composition of the gases with the low arch, while the heavy lines indicate the gas composition with the high arch.

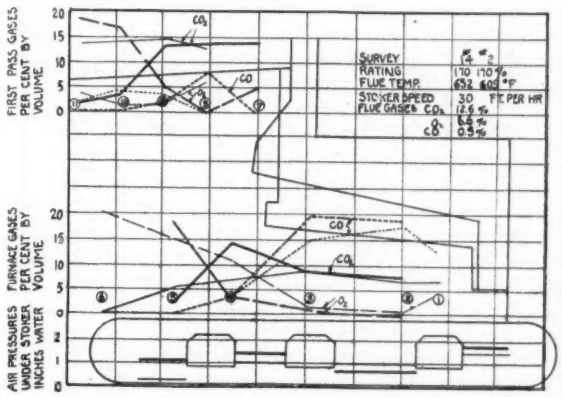


FIG. 3. EFFECT OF RAISING THE FRONT ARCH

If raising the front arch is to improve combustion the per cent of CO_2 found in the gases entering the boiler must be higher and the per cent of CO must be lower than with a low arch. It was impossible to determine exactly what weight to give the analyses at the various points but if we assume that the points apparently in the main gas stream should be weighted according to the rough measurements of velocity that were made, points 9, 10 and 11 would have a weight of 4 to a weight of 1 for points 7 and 8, with the low arch in service. With the high arch points 7, 8 and 9 would have a weight of 4 and points 10 and 11 a weight of 1. Using the foregoing approximation the average composition of the gases entering the boiler shown in Fig. 3 is as shown in Table I.

TABLE I. EFFECT OF LOW AND HIGH ARCH ON GAS COMPOSITION

Gas Composition entering the boiler	CO_2	O_2	CO	N_2
With low arch	13.8	2.9	2.9	80.4
With high arch	12.1	5.4	2.8	79.7

From the above it is evident that there was little change in the amount of combustible gas entering the boiler but there was a reduction in the amount of CO_2 and increase of oxygen so that the gas composition was not favorable to the high arch.

It is evident that if more air were forced through the refuse it would rise directly to the boiler past points 10 and 11 without coming into contact with the main stream of gas at all. With the low arch such an increase in air supply raised the excess air, but with a high arch the

effect would probably be worse in that none of the combustible gas would be eliminated by the accompanying increase in excess air.

Effect on Combustion of a Partition in No. 2 Air-Chamber

No. 2 air-chamber is that space under the grates between the first and second-wind-boxes. The distance between the sides of these two wind-boxes, in the direction of the movement of the grate, is nearly twice the distance between wind-boxes 2 and 3. It is understood that the stokers were originally installed with a partition in the second air-chamber, but that due to the design of the air ducts it was impossible to supply air to the front part of the section and to section 1 from the first wind-box.

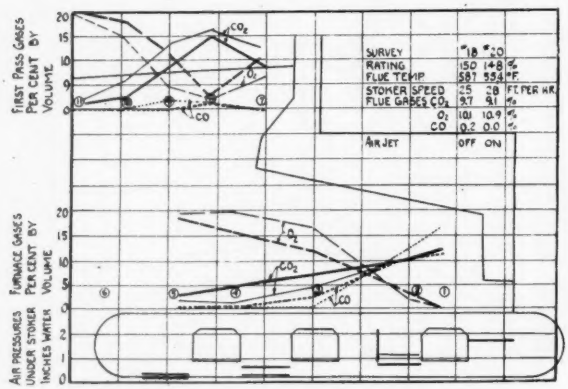

First Pass Gases Per Cent by Volume
Furnace Gases Per Cent by Volume
Air Pressures Under Stoker Inches Water
CO2
O2
CO
SURVEY 18 20
RATING 150 148 %
FLUE TEMP 587 554 °F
STOKER SPEED 25 28 FT. PER HR.
FLUE GASES CO2 9.7 9.1 %
O2 10.1 10.9 %
CO 0.2 0.0 %
AIR JET OFF ON

FIG. 4. EFFECT OF AIR JET WITH PARTITION IN NO. 2 AIR CHAMBER

For this reason the partitions were removed pending the necessary changes in air-ducts and were never replaced.

A partition was installed in each of the stokers of the boiler on which the investigations were made and is indicated by the vertical line in No. 2 section on the background of Fig. 4. The composition of the furnace gases at the several points is shown by the light weight lines in the above figure. In Fig. 4, at low rating the shortness of the fire is clearly shown. Because the CO formed at the front of the fire had to pass under the front arch for a considerable distance before rising to the boiler and because oxygen was present in the gases below the arch, due to the short fire, there was somewhat less CO in the gases entering the boiler. At the same time the greater amount of oxygen passing through the fuel bed raised the excess air in the flue gases somewhat as shown by a comparison of the flue gas composition for survey 14 (Fig. 3) and survey 18 (Fig. 4) at nearly the same rating.

Effect of an Air Jet on Combustion

In Fig. 4, the heavy lines show the effect of an air jet on combustion. The air jet was introduced through the sidewall of the furnace about a foot below the end of the front arch and was supplied with air from a railway-type compressor which gave a pressure of about 25 lb. at the nozzle of the jet which was formed from a piece of ½-in. pipe. The differences in the composition of the gases over the fuel bed were caused by slight differences in the lengths of the fire.

As shown in Fig. 4 the oxygen at points 7 to 11 inclusive was higher with the air jet in service, and the CO_2 and CO were lower. Thus the air jet reduced the amount of CO in the gases entering the boiler but it accomplished this with a substantial increase in excess air.

At high ratings, also, a reduction in the amount of CO in the gases entering the boiler took place accompanied, as at low ratings, with a decrease in CO_2, and an increase in oxygen when the air jet was in service.

The effect of an air jet in burning out CO seems to be balanced by an increase in flue gas loss due to excess air so that little real benefit is derived from the use of such a jet. In addition, it is illogical to provide an air supply above the fire if air can be forced through the refuse and properly mixed with the combustible gases. That the logical place for the admission of any air necessary for combustion is through the refuse is evident from the fact that air entering the furnace in such a manner must gasify some carbon and so reduce the loss due to combustible in the refuse.

In order to simulate the action of a rear arch without waiting for its construction, a system of steam jets was introduced across the stoker at point No. 6 at the rear of the furnace. The steam jets were constructed by inserting sixteen ⅛-in. pipe nipples into a 1-in. pipe, 8 ft. 8 in. long. It is understood that these steam jets would probably be more effective than an arch because of the high velocity of the steam, but it was assumed that they would

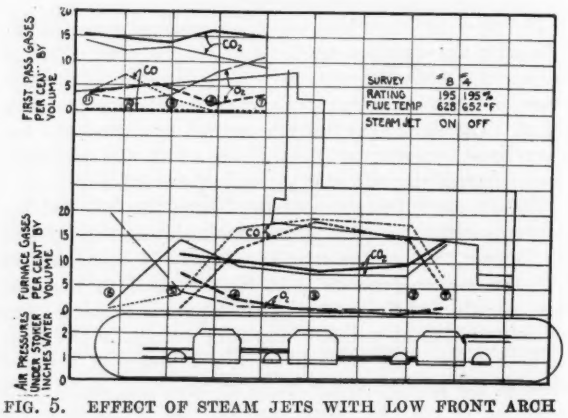


FIG. 5. EFFECT OF STEAM JETS WITH LOW FRONT ARCH

give an indication of the probable effect of directing the air rising through the refuse toward the front of the furnace where the necessity for such air has been shown.

The effect of the steam jets with the low arch in service is shown in Fig. 5. In this figure the lighter lines indicate the gas composition under normal operation and the heavy lines the composition with the steam jets in service. The combustion of the coal on the grates is, of course, unaffected by the steam jets. In the first pass, however, the effect of the additional air and the mixing action of the jets is evident. The air rising through the refuse is forced forward by the action of the steam jets and mixed with the main gas stream. The oxygen in this air is thus brought into contact with the combustible gas and combines with it burning the CO and increasing the CO_2. The composition of the gases in the first pass shows that by the time the gases have reached the boiler tubes the CO is entirely eliminated. The flue gas temperature, averaged across the uptake, shows a reduction of 20 deg. F., but since this average includes both stokers and the steam jets were applied to only one, it is fair to assume that the reduction was twice as great, or 40 deg., over the

stoker on which the experiments were carried out. A comparison of the two sets of analyses of the gases entering the boiler by means of averages weighted as formerly is given in Table II.

TABLE II. GAS ANALYSIS WITH AND WITHOUT STEAM JETS

Gas composition entering the boiler	CO_2	O_2	CO	N_2
With steam jets	14.8	4.0	0.1	81.1
Without steam jets	12.7	3.7	3.7	79.9

From the results given in Table II it is evident that steam jets gave the greatest improvement of any change discussed thus far.

Because some of the arches in the boilers at the plant had been raised, it was desirable to learn the relative effect of steam jets on the combustion in a high arch boiler. The curves in Fig. 6 show the results of an investigation on a high arch boiler with and without steam jets. The heavy lines indicate the composition with the steam jets in service and the light lines the composition under normal operating conditions.

The fact that the earlier turning of the main gas stream and the shorter distance between the arch and the boiler tubes makes it more difficult to mix the gases from the rear of the stoker with the combustible gas is shown by the lesser degree of success attained by the use of steam jets. It can be seen that the CO in the gases entering the boiler has been reduced in amount, but not eliminated, while the CO_2 at points 10 and 11 is raised somewhat. The comparison of the weighted averages of the gas composition is shown in Table III.

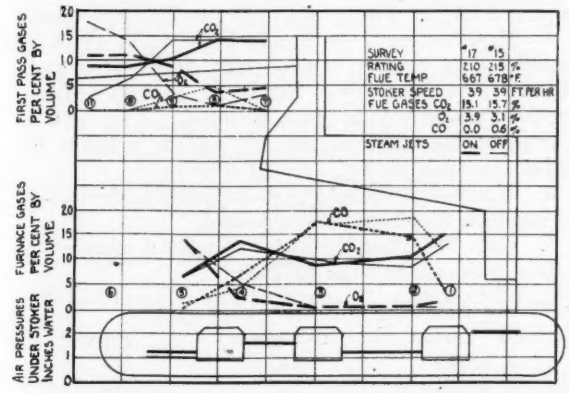


FIG. 6. EFFECT OF STEAM JETS WITH RAISED FRONT ARCH

TABLE III. EFFECT OF STEAM JET ON WEIGHTED AVERAGES OF GAS

Gas composition entering the boilers	CO_2	O_2	CO	N_2
With steam jets	12.4	6.6	0.5	80.5
Without steam jets	13.0	4.5	2.2	80.3

The reduction in the amount of CO entering the boiler was sufficient to eliminate the loss from CO in the stack as shown by the analysis of the simultaneous sample of flue gases.

It is evident therefore that steam jets (used to simulate a rear arch) were effective with a high arch but not as effective as they were with a low arch. This fact is of importance in deciding the best arch arrangement over a chain grate stoker burning small sizes of anthracite.

Actual Effect of a Rear Arch

In order to confirm the conclusions drawn from the action of steam jets a Detrick flat-suspended arch was installed in the rear of a low arch furnace. The rear arch was suspended 10 in. above the grate and extended 5 ft. forward from the bridgewall. The boiler was opened for several days at ratings varying between 250 and 270 per cent in order to learn the ability of the arch to withstand the heat of the furnace before a study of the furnace gases was undertaken. It was noted during this preliminary operation that the dropping of particles of solid combustible matter from the gases to the ashpit was stopped completely and that this material dropped to the roof of the suspended arch instead. On the roof of the suspended arch the combustible material seemed to burn out leaving a layer of ash which increased in thickness until it flowed slowly toward the grates forming "whiskers" on the nose of the arch. The nose of the arch itself was brilliantly incandescent although a layer of clear gas from the last stoker section seemed to cling to the surface of it. In rising to the boiler there seemed to be an expansion of the gas stream so that the whole width of the first pass was taken up by the gases entering the boiler.

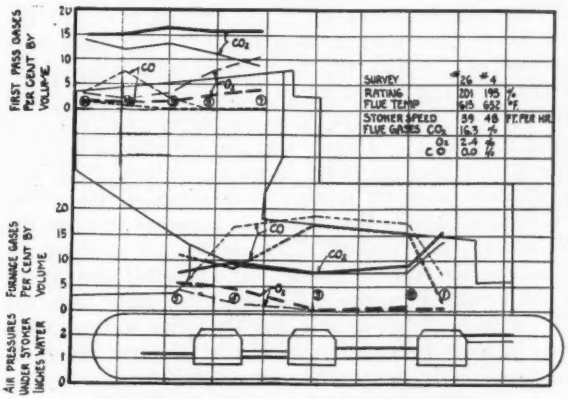


FIG. 7. ACTUAL EFFECT OF REAR ARCH

The shape of the arch and its relation to the furnace is shown in Fig. 7.

In Fig. 7 the results of a study of the furnace gases with the rear arch (heavy lines) are superimposed on the results of a study of the furnace gases without the rear arch installed (light lines). Over the fuel bed the gas composition is different although this is obviously not due wholly to the rear arch. The air pressure in No. 4 air-chamber was maintained considerably higher with the rear arch in service and the refuse passing over the end of the stoker appeared well burnt out.

The analysis of the flue gases shows a favorable condition. The flue temperature shows a reduction of about 35 deg. F. which in itself is the equivalent of a per cent saving.

Furnace for Burning Small Sizes of Anthracite

It is the function of a chain grate stoker furnace to ignite the coal, as it enters on the grate, and to mix the gases, from different sections of the stoker, so that combustion will be completed, with as little excess air as possible, before the gases enter the boiler.

Ignition is caused by radiation from incandescent brick work to the green coal as it enters on the grate. Ignition can be improved mainly by increasing the area of incandescent surface, seeing the coal by actually building more of such surface, and by decreasing the thickness of the ignition arch so that less coal will be in its shadow, or by both of these changes. It has already been pointed out that the nose of the rear arch became incandescent at high ratings and was hot at low ratings, and, since this part of the arch looks toward the front of the furnace, radiation from it must be received by the green coal. Because the bridgewall never was heated above a dull red heat, the radiation from it to the green coal must have been less than from the nose of the rear arch, therefore, ignition was hastened by the addition of this form of arch.

The remaining function of the furnace is to mix the products of combustion so that the combustible gases from one part of the grate will be supplied with oxygen from another part and burned before they enter the boiler. The investigations reported in this paper were carried out on a Dutch oven type of furnace and the indications are that some such type is necessary to produce mixing. Air and combustible gases are present at the front of the stoker and some arch over this section is necessary to force the two streams into contact. Because the air entering the furnace at the front is generally insufficient to supply all of the necessary oxygen, the combustible gases from the front must be forced to pass over the refuse section of the grate in order to come in contact with the free oxygen in the gases rising from this section. This action can be accomplished by placing the stoker completely under an arch and thus prevent any of the gas from entering the boiler until it had passed over the refuse section.

This form of furnace would have obvious disadvantages from the standpoint of upkeep because intense gaseous combustion would probably take place over the refuse section and the arch would be subjected to the resulting high temperature at this point. It is well, therefore, to shorten the main arch from this extreme length to a length that will permit radiation to the boiler to cool the brick work at the point where the most intense combustion will take place. If the front arch is shortened in this manner it is necessary to install a rear arch to prevent the gases from the refuse section from rising directly to the boiler and to force them to travel toward the front of the furnace far enough to insure their mixing with the main stream containing combustible gas. The front arch should be low enough to insure the gases having a high enough velocity so that their momentum will carry them beyond the end of the front arch over the rear arch to the bridgewall. Combustion under the front arch can be made more incomplete than normally, if advisable, by a decrease in the air supply at the front; and the necessary oxygen for the completion of combustion can be supplied by carrying high air pressure under the refuse section of the grates.

The details of the dimensions of such a furnace would vary with the height of the setting available because the higher the setting the more time there will be available for the completion of combustion. Conversely, the lower a setting is, the more effective must be the action of the mixing devices in order that combustion be completed before the gases reach the boiler. It seems necessary, however, to utilize arches in the manner suggested to give the gas streams from the front and from the rear of the stoker, velocities in opposite directions to insure the completion of combustion in the furnace.

Simplification of Hot Water Storage Tanks

AT THE meeting held Jan. 28, at the Department of Commerce, the manufacturers of hot water storage tanks submitted to the Department's Division of Simplified Practice, tentative recommendations covering sizes and dimensions of these commodities. These recommendations, if generally adopted by manufacturers, distributors, and users of these tanks, will represent a reduction from over 250 varieties as now made to five standard sizes and two working pressures. The tentative recommendations are as follows:

1. Dimensions.

Length in feet	Diameter in inches	Capacities in U. S. gallons
5	30	180
6	36	315
7	42	500
10	42	720
14	42	1000

These sizes are to be made in two working pressures, viz., 65 lb. per sq. in., and 100 lb. per sq. in.

2. These tanks are to be made interchangeable for either horizontal or vertical installations.

3. Tappings. There are to be five (5) tappings in each tank—1 in the center of each head; 2 in the shell, each to be centered 8 in. from the edge of the sheet, and 1 in the shell centered 30 in. from the edge of the sheet measured from the concaved end. All tappings in all sizes of tanks are to be 2 in. All threads are to be standard pipe thread.

4. Manholes are to be standard size 11 by 15 in. of pressed steel, with cover of the "Crab" type held in place with the conventional "Crow foot." In tanks 30 in. diameter, the manhole must be put in the head. In tanks 36 in. or larger in diameter, the manhole may be either in the shell or the head.

5. Handhole is to be 4 by 6 in. with cast-iron cover. The handhole may be located as desired.

6. Coils for either horizontal or vertical installations of these tanks are to be as follows:

Tank Dimensions Feet	Inches	Diameter of Pipe in Inches	Lineal feet of Pipe
5	30	1¼	14
6	36	1½	18
7	42	1½	22
10	42	1½	34
14	42	1½	50

7. In certain installations where greater capacity is desired, it is recommended that two or more tanks of appropriate size be used,—thus affording one for reserve in event of failure of the other, and making for easier installation or replacement in cases where use of one extremely large or special tank would be difficult. It is believed that the reduction in stocks of large size sheets and plates, together with other economies resulting from manufacturing these simplified sizes in large quantities, will more than offset the cost of the additional piping when two or more of these tanks are used.

These tentative recommendations are to be put before all interested groups for consideration with a view to securing their adoption at a general conference to be held at the Department of Commerce at some future date.

Mechanical Control of Boiler Feed Water

DIVERSE DEMANDS OF ENGINEERS IN FEED WATER REGULATION PRACTICE ARE BEING MET BY MODERN REGULATORS. BY C. E. WOLFF

MODERN boiler plant operation consists almost entirely of the control of the variables entering into steam generation, the three principal ones in boiler operation being fuel, air and water. It is obvious that with the most perfect control of draft and fuel it is impossible to effect the most efficient results and economies without mechanical regulation of the other variable, namely, the feed water.

A survey of modern boiler plants among central stations and manufacturing interests discloses that engineers have come to the conclusion that mechanical regulation is necessary and is to be preferred in every way to hand regulation. With the necessity of boiler feed water regulators established, engineers are now turning to the second problem of mechanical control and determining the most desirable elements that enter into scientific regulation.

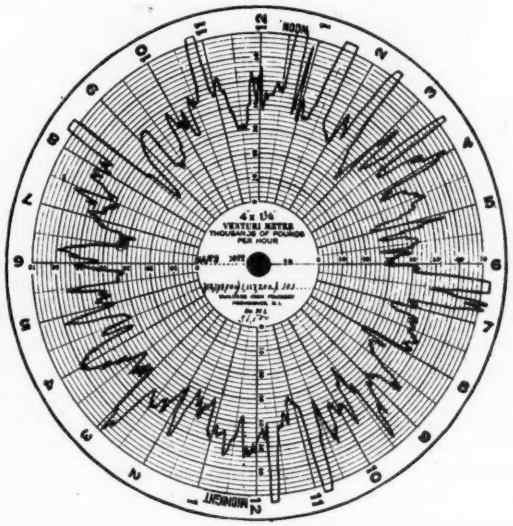


FIG. 1. RECORD OF WATER FLOW THROUGH LOW LIFT REGULATING VALVE

From exhaustive tests and practical experience, engineers have established positive requirements which must exist in feed water regulators for effective results. Some of these are set forth in the following:

VALVE CAPACITY DEPENDS UPON AREA AND PRESSURE DROP

To determine the size of the valve regulating the feed supply merely by the feed line diameter is little better than guess work. The quantity passed by a valve depends not only on the area but also on the pressure drop across it. The best results are accomplished by having the valve body itself of the diameter of the feed line and proportioning the valve area for the minimum and maximum evaporation requirements and water pressure differential existing in the individual plant. With the proportioning of valve area, engineers are insisting that the valve travel of the piston controlling the quantity of water to be passed, be as great as possible. In other words, a valve travel of not less than ¾ in. is desired. Figures 1 and 2 show the comparison of the results of a low lift valve and a high lift valve.

With the increasing tendency toward higher operating pressures, there is the constantly increasing demand for reliability in boiler feed water regulators. Cast steel control valves are universally used on high pressure boiler installations and the internal fittings of the valve are of solid monel metal. Regulators are being built for operating pressures of 1200 lb. and are being installed on boilers of 3000 hp. to operate at 400 per cent of rating.

WATER LEVEL PRACTICE

There is a tendency on the part of engineers to abandon the traditional fixed water level. With the advent of the steam turbine, high water levels are not desired and it is becoming the practice now to carry the average water level below the center line of the main drum of the boiler. The

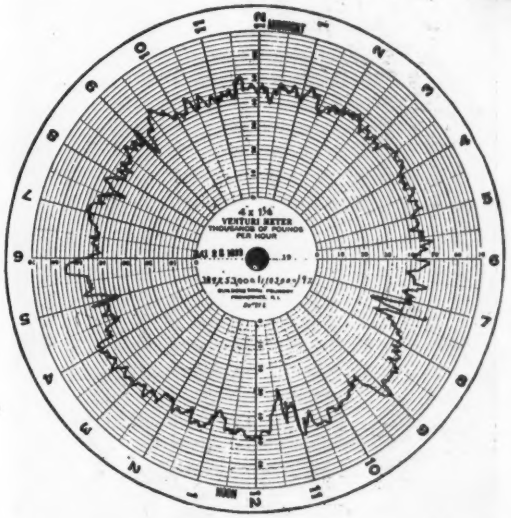


FIG. 2. FLOW CHARACTERISTIC OF HIGH LIFT VALVE

range through which the water level moves from normal load to peak is also being carefully considered, the general practice being to vary the level more, this being dependent on the type of boiler and local load conditions. To meet the requirements of varying levels, engineers insist that provision be made in the design of the regulator for a liberal adjustment of working levels, with the boiler under load.

MAKING REGULATORS INDICATING

Because of the size and height of modern boiler settings, the feed water regulator is in many cases invisible from the operating floor level. Therefore, engineers have brought out the desirability of having the regulator operation constantly before the boiler attendant for observation. Valve movement indicators are particularly adapted to that type of regulator having a fixed and unvarying relationship existing at all times between movement of the water level in the actuating agent and movement of the valve controlling the feed flow. It will be evident that by keeping the pressure drop across the valve constant, that the valve

movement indicator becomes an indicating water meter, provided a determined area of the valve ports had been embodied in the design of the valve. Figure 3 shows one method for installing a valve movement indicator.

Sensitiveness

Since the water level of a working boiler is dependent on furnace and load conditions, the feed water regulator should feed continuously and provide a given rate of flow for a given water level. Friction in a continuous feed variable level type regulator is the cause of hunting and spasmodic action of the valve controlling the feed flow. For smooth, even feed the feed water regulator should have a large actuating force and little friction. Thus, the ratio

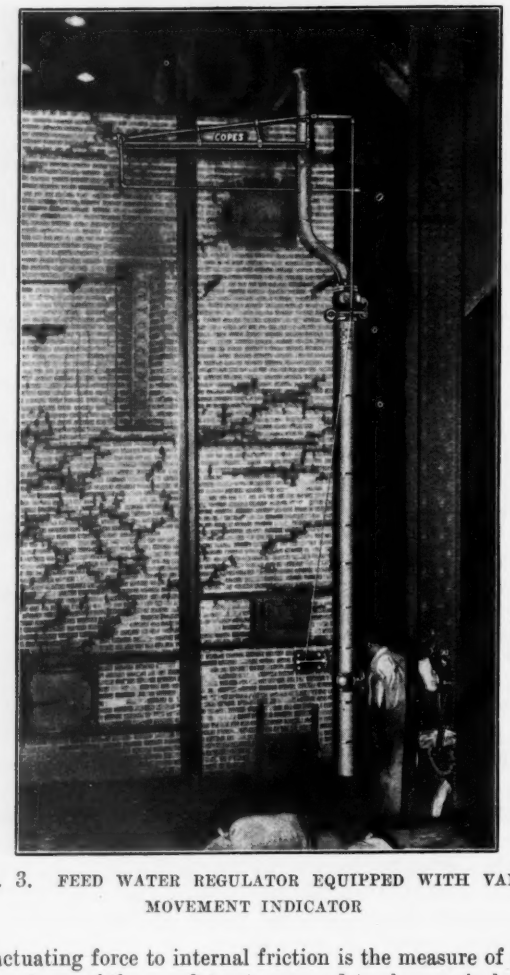


FIG. 3. FEED WATER REGULATOR EQUIPPED WITH VALVE MOVEMENT INDICATOR

of actuating force to internal friction is the measure of the promptness of the regulator to respond to changes in level. Figure 4 illustrates most clearly the sensitiveness and accuracy of operation of a modern type regulator. Each movement of water level is simultaneously accompanied by movement of the valve controlling the feed to the boiler. Thus, a given rate of flow for a given water level is provided at all times.

Dual Control

Engineers are beginning to understand better the vagaries of water level in the drums of a boiler. The proper distribution of the relatively cold feed is receiving greater attention because of its influence on boiler rating, maintenance, etc. For this reason it is almost standard practice, now, to have two regulators per boiler on large units, and adjust them accurately to feed the same amount to each side.

An example of the accuracy of dual flow control is shown by the positive regulation of two thermostatic regulators operating on a large unit boiler. In 24 hr. the water fed by one regulator did not vary 1/5 of 1 per cent from the amount fed by the other regulator.

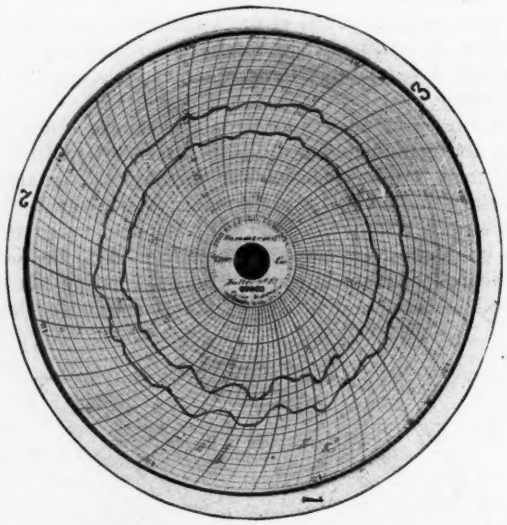


FIG. 4. RELATION BETWEEN WATER LEVEL AND OUTER PIN RECORD AND VALVE MOVEMENT

Boilers with small liberating surface in which the water level varies greatly with slight changes in pressure or load, should be equipped with longer gage glasses, and the level permitted to swing through its natural travel. On such boilers the feed water regulators should be set for a wide range in level, and thus not be affected by changes in level which ordinarily would cause the regulators to give intermittent operation. In fact, boiler and operating load characteristics vary so much that engineers are specifying provision for considerable adjustment, and thus permit the operator to set the regulators for the particular conditions.

Recently a 50,000-kw. turbo-generator has been designed as a three-cylinder machine, the high-pressure and the intermediate elements being connected tandem to one generator and the low-pressure unit being a double-flow machine driving a generator, all elements running at 1800 r.p.m. One novel feature of this unit is the use of twin vertical surface condensers, one on each side of the machine, with their upper water boxes above the turbine room floor. The steam leaving the high-pressure turbine is conducted to the boiler room and reheated to 700 deg. F. before entering the intermediate-pressure element.

It is perhaps not generally known that a small storage battery such as is used in an automobile for ignition and lighting purposes, and weighing about 60 lb., can deliver over 2,000,000 ft.-lb. of energy. This is sufficient to raise its own weight to a vertical height of over 6 mi. In starting an automobile engine, the storage battery is often required to develop power at the rate of two electrical horsepower.

Turbine Pump for Boiler Feeding

RECENT INSTALLATIONS IN GREAT BRITAIN INDICATE GROWING USE OF TURBINE PUMP. BY C. H. S. TUPHOLME

INCREASING interest is being taken now in efficient boiler feeding methods, and the movement in this direction is reflected in the gradually increasing number of installations of turbine pumps for boiler feeding in place of the ordinary types. In the special province of boiler feeding, during recent years, small steam turbines have been employed coupled to multi-stage centrifugal pumps, a type involving more or less complicated construction, with attendant liability to breakdown, excessive

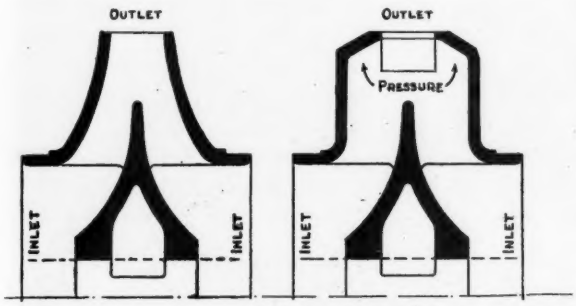


FIG. 1. COMPARISON OF CENTRIFUGAL AND REES-ROTURBO IMPELLERS SHOWS LATTER HAS LARGE CAPACITY PRESSURE CHAMBER

weight and large initial cost. Further, they work uneconomically on account of the low peripheral velocity of the small turbine.

Advantages derived from the turbine type of drive have led power plant engineers in Britain to a study of the application of this drive to the various forms of power plant auxiliary machinery, including boiler feeding. Most power plant engineers are well acquainted with boiler feed pumps of the reciprocating type, and, when first encountering a pump operating on the turbine principle, they realize that they have a machine based on quite different principles. Indeed, the turbine pump is merely the natural result of a process of evolution from the centrifugal type, for it has long been known that it is possible to raise water to appreciable heights by means of the ordinary centrifugal pump, but at the expense of losses which are sometimes extremely heavy. These losses are due to the hydraulic friction and whirling action of the pump. These friction losses could be traced to the imperfect conversion of the velocity energy of the water into pressure energy after leaving the disc. Thus, as a result of these factors, the degrees of efficiency attained were mediocre.

In the centrifugal pump, the water, on entering the pump mechanism, is immediately forced by the action of a vane wheel or impeller to assume a vortex motion, thus acquiring a high velocity and an increase of pressure on leaving this impeller. As far as the impeller action is concerned, the pressure produced is the only quality of any immediate value acquired by the water in passing through this action and, unless special devices are utilized, the velocity energy of the water will not add proportionately to the pressure, but will largely be dissipated.

Production of such a velocity is necessitated by the action of the impeller, and the problem then confronting the designers was to contrive some means for the conversion of this amount of kinetic energy given to the water into pressure energy, and so to increase the head against which the water can be delivered for a definite speed of the impeller. The arrangement employed for this operation and the subsequent conversion of the energy form the basis of the successful progress of the turbine pump. The water, leaving the impeller, enters a number of passages, usually called a diffuser, and a large part of the kinetic energy which disappears is here converted into pressure energy, in accordance with the law originated by Bernoulli.

The proportion of kinetic energy to pressure energy produced by the impeller can be varied between wide limits by variations in design, thus making practicable latitude in design so enabling the designer to turn out a pump best suited for the special requirements of each installation.

TURBINE PUMP PERMITS VARIABLE OUTPUT

One of the chief features which distinguishes the turbine centrifugal pump from the reciprocating type is that

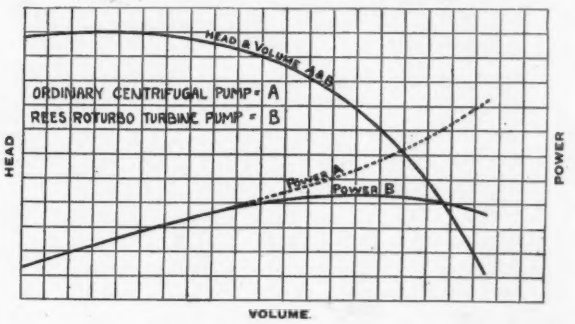


FIG. 2. CHARACTERISTICS OF CENTRIFUGAL AND TURBINE PUMPS

the output of the former can be varied widely, either by simply throttling or by altering the speed of rotation. The first method is applicable to all cases where an electric motor at uniform speed is the source of power or where for other reasons it is necessary to maintain a uniform speed. It is evident, however, that if the pump is throttled down from normal to 50 per cent output, the efficiency at 50 per cent is considerably lower than that at the normal output. If, therefore, a motor or an engine with allowances for speed regulation can be employed as motive power, the second method will give much more satisfactory results. A turbine pump can thus be arranged to give a wide range of outputs by means of altering the speed and without affecting the efficiency.

Turbine pumps are eminently suited for boiler feeding purposes where a total quantity of 50 gal. and upwards per min. is essential. The pump can be driven direct by an electric motor of either the continuous or alternating current type, or by a direct-coupled steam turbine.

When the water is supplied to the pump under a small head, the pump is capable of dealing with hot feed, and the quantity can be regulated over an extremely wide range, either by slightly varying the speed or simply by throttling the delivery.

In operation the turbine pump is silent and delivers a continuous stream of water without any pulsation. The amount of floor space taken up is small and it will run continuously with the minimum of attention, while the efficiency both at full and at reduced loads is high. As the water is delivered continuously and without shock, the trouble occasionally experienced with leaky joints and broken pipes is reduced to the minimum.

Only occasionally does it happen that the conditions under which turbine pumps are required to operate are identical in any two cases, owing to the wide differences in the head against which the pumps are to work, the

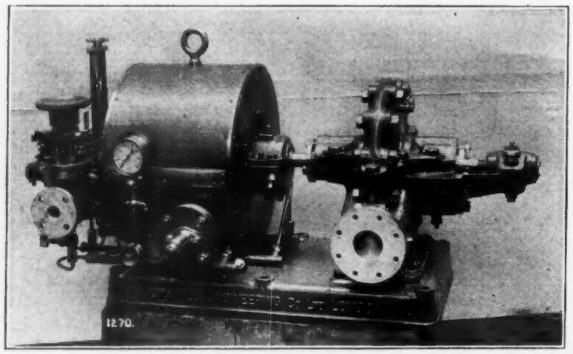


FIG. 3. GWYNNE BOILER FEED TURBINE PUMP SET

quantity of water to be pumped, the dissimilarity of the sites where the machinery is to be installed and the special conditions varying with the size of the plant and the speed. It is of the greatest importance, when considering the installation of a turbine pump to study carefully not only the conditions under which it is to operate, but also any special features attaching to the motive power.

Wherever the pump is direct-coupled to an electric motor running at a constant speed, any variation in the output of the pump around the normal is permissible only if it can be accomplished without increasing the power required much above that at the normal output. This is because the driving power must be determined by the power absorbed at the normal output.

In cases where the head of the pump varies from maximum to zero, and the speed remains approximately uniform, the maximum horsepower will be required under the conditions between normal head and zero head. It is important that the maximum horsepower be kept as low as possible at this point, whether the pump is driven by an electric motor or other motive power, so as to prevent overloading due to possible uncontrollable factors in the head.

In many cases of high lifts, the most economical arrangement is to divide the total lift of the pump between two or more individual impellers. These impellers are either all mounted upon the same spindle inside the same casing, or, for high heads making a large number of impellers imperative, they are grouped in two casings. The water is arranged to traverse each impeller in succession, being conveyed from the delivery chamber of one impeller to the center of the next by passages specially designed to ensure a minimum loss of head through friction and whirls.

A point of considerable importance is the adoption of proper materials for the construction of the various internal parts. Owing to the vigorous mechanical action of the water in one type of pump, for example, special bronze is usually adopted for the construction of the impeller and guide blades or diffuser. In this pump the spindle is generally of high grade nickel steel completely encased in bronze or gun-metal sleeves. Where non-corrosive water has to be dealt with, the pump can be made of cast iron.

Where the spindle enters the pump casing, a stuffing-box of improved construction is fitted, which permits of a high speed of rotation without the possibility of seizing and which is also provided with automatic water sealing to prevent the entry of air into the pump with the consequent reduction of efficiency. The bearing at the driving end is located entirely outside the pump casing and lubricated by means of self-oiling rings. The bearing at the other end of the pump is arranged inside the pump casing and lubricated by a Stauffer "Tell-tale." Where necessary, both bearings are situated outside the pump casing and lubricated by self-oiling rings.

Of considerable interest is the development of the Weir turbine feed pump into a unit rotary machine, in which production has been standardized. It is simply constructed and has few working parts; it is automatic in action, noiseless and free from vibration. It is also capable

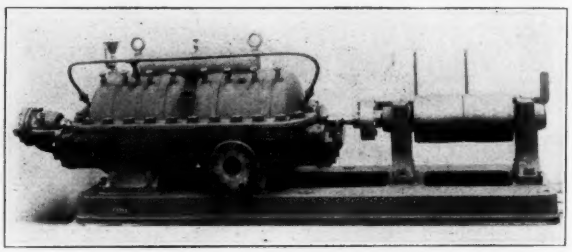


FIG. 4. EIGHT-STAGE ROTURBO TURBINE PUMP

of discharging against the highest boiler pressures and is adapted to operate in conjunction with the usual types of boiler feed regulators, and in combination with ordinary reciprocating pumps. The exhaust steam contains no oily residue, and is therefore available for heating the feed water by direct contact.

This pump consists essentially of a steam turbine of the impulse type, having one pressure and several velocity stages, operating in conjunction with a single-stage centrifugal pump of special design. The turbine casing and bearings are divded horizontally, the lower portions being embodied in the general framework or base. This framework is extended at one end to form a flange to which the pump casing is rigidly secured. By this arrangement, the pump impeller is carried on the overhanging end of the turbine shaft.

Admission of steam to the turbine is primarily regulated by a stop valve of the ordinary screw-down disc type. By means of a spring loaded piston and dashpot arranged on the valve spindle, and controlled by a trip gear in conjunction with an emergency governor, this valve is enabled to act as the emergency or safety valve as well. Immediately the predetermined speed limit is attained the action of this governor closes the stop valve, completely shutting off steam from the turbine.

Normally the pump discharge pressure is controlled by a pressure governor, which maintains a constant discharge pressure at the pump irrespective of any ordinary fluctuation in the steam pressure or in the quantity of water discharged. The set is thus self-regulating for all ordinary

changes in either water or steam conditions. The Weir set is turned out in capacities ranging from 7000 to 50,000 gal. per hr.

Of the Rees-Roturbo pump, the distinguishing feature is the construction of the impeller which takes the form of a large capacity drum or pressure chamber, instead of the ordinary flat disc, runner or impeller. The object of this design is to obtain by centrifugal force inside the pressure drum, a constant hydraulic pressure equivalent to the height of the working lift. The full pressure having been secured inside the revolving drum, it becomes possible to throw back the water tangentially without sacrificing efficiency. In the rim of the drum are a series of turbine nozzles which point in a rearward direction and form short passages imparting to the water a resultant velocity, which at the highest efficiency point or normal duty is half the peripheral velocity of the drum.

As a result of this construction, only 25 per cent of the pressure generated in the drum is converted into velocity, the water thus leaving the impeller at 75 per cent pressure and 25 per cent velocity. The fixed diffusers have, therefore, only to reconvert 25 per cent of the total pressure. This permits of the use of a simple form of diffusers or cutwaters, with large clearances all round the impeller. Wear and tear is thus reduced to the minimum, and the necessity of renewable tips is avoided. Hence the efficiencies of these pumps may be said to be permanent efficiencies, due to the low velocities of the water, and to the fact that the results depend much less on the action of the diffusers than in ordinary centrifugal pumps, which are subject to considerable losses in efficiency on account of wear.

In this pump the revolving drum may be considered as a combination of a centrifugal pump in series with a turbine, with a large capacity pressure chamber or hydraulic accumulator between the two portions, the vanes between the eye and the rim forming the centrifugal pump proper and the short rim blades the turbine. It will be seen that the pump will always be discharging into a constant pressure, which is ideal for a centrifugal pump, and the turbine will always be discharging from a constant pressure, which is ideal for a turbine. Therefore if the head varies or is reduced below the normal duty of the pump, the turbine blades extract the energy of the increased speed of water through the drum and convert into torque this energy which would otherwise be wasted, and would expend itself in wear on the metal surfaces. It follows that an overload on the driver is impossible. Such a pump, when running at its normal speed, may be put to work on any head below that for which it is designed, without exceeding the rated horsepower; at the same time it will work with high efficiency over a wide range of lift, delivering an increased volume of water with decrease in head. On hydraulic short circuit, or zero head, the volume increases to about 200 per cent of the normal.

IN GENERAL TERMS regulation of a transformer is the variation in secondary voltage with variation of load and power-factor. The greater the load and the lower the power-factor, the greater is the drop in voltage as the load is increased. The voltage drop varies directly as the load, provided the power-factor remains constant. A leading power-factor tends to raise the voltage, and a lagging power-factor to lower it. On non-inductive load (a load of 100 per cent power-factor) the regulation, as a rule, exceeds the copper drop by only a small amount.

Progress in Hydroelectric Practice Outlined*

IN AN address delivered recently before the Boston Society of Civil Engineers, W. M. White, manager and chief engineer of the hydraulic department of the Allis-Chalmers Mfg. Co. reviewed at some length the development of hydroelectric practice touching on the types of units suited for various heads, draft tube design, the perfection of the integral governor and the economic aspect of automatic stations.

After a preliminary review of the water power resources and developments of America as compared with other countries, the speaker launched into the subject of the types of units best suited for various heads.

For low heads up to 20 ft., the standard open flume construction is still generally used. Rarely is a spiral form used although in some cases a pointed nose is placed in the rear of the flume to direct the flow into the guide chamber. The modern tendency toward large units, involving of course, large diameter runners, has made the vertical type unit more efficient and economical. This tendency has meant decreased speed which of course means a larger and more costly and less efficient generator, hence there has been a demand for higher speeds. To meet this demand the high-speed propellor type runner has been developed.

As another range, heads from 20 to 60 ft. were considered. Here the tendency has been to use concrete spiral casings and to make the turbine with outside operating mechanisms. In this design some of the water particles travel half way around the wheel, whereas in the usual cast-iron spiral case some of the water makes practically a complete circle around the runner.

From 60 to about 300 ft. is the next natural range and might be called "The Metal Spiral Range." It is within this range that about 70 per cent of all the potential water power are to be found. The plate steel circular section scroll case or spiral is generally used for this range. This form of casing is a logical development since it is merely and extension of the plate steel penstock around the turbine. For the range between 300 and 850 ft. cast steel casings have been used exclusively.

Reaction type Francis turbines are employed for heads up to 850 ft. The range of the impulse wheel overlaps that of the Francis turbine beginning probably at 500 ft. coming into exclusive range at 850 ft. and having no upper limit except that imposed by the strength of materials. The upper limit of application is now 3000 ft.

DRAFT TUBE

Greatest advances in the art of developing power from water have been made in the improvement of the form of the passages from the runner to the tail race. The ever-increasing size of the units has meant larger diameters of runners and the ever-increasing speed for given types has meant that greater percentage of the total energy is discharged from the runners. As the percentage of energy discharged has increased, the energy lost in the draft tube has also increased, a condition which has resulted in the runner being set nearer to the level of the tail water. The draft tube has had to be made larger in diameter and of a shorter radius of curvature which has meant less regain. The high specific speed of runners has caused the water to

*Abstract of paper published in the Journal of the Boston Society of Civil Engineers.

leave the runner in a greater state of whirl than formerly. The hydraucone draft tube provides for radially extending passages in which the whirling water may be made to pump itself out against the tail water level, thereby increasing the efficiency of the wheel.

The hydraucone provides a means for regaining the discharged energy effectively within a short space measured in the direction of flow from the wheel, thereby saving excavation; it has radial passages and provides for the regain of the whirling energy leaving the high specific speed wheels. A new form of curved tube for utilizing a portion of a hydraucone has been developed and good results obtained. This type is characterized by the lowering of the roof of the draft tube to form a constriction at the discharge end of the bend.

The radially extending passages of the hydraucone draft tube provide for regain of the whirling water discharged from the runner when the turbine is operating at part load. The hydraucone has an efficiency of about 80 per cent.

Specific Speeds

Limits of specific speed which may serve as a basis for the discussion of this question are given by the relation:

$$Ns = [5050 \div (H + 32)] + 19$$

As a rule runners of higher specific speeds than those indicated by the formula will not pit. In some cases, however, it is more economical to select higher specific speeds than those indicated because of the reduction in cost and the increased efficiency of the generator, as contrasted to the increased cost of replacements of the pitted runner. In selecting the limits of specific speed for a particular installation, the varying cost of the generator in regard to speed should be carefully considered. In the case of large generators, we have found that there is a definite point of flexure in the curve of cost plotted in respect to speed and in large units this point of flexure frequently corresponds to a lower specific speed than that indicated by the formula.

Governors

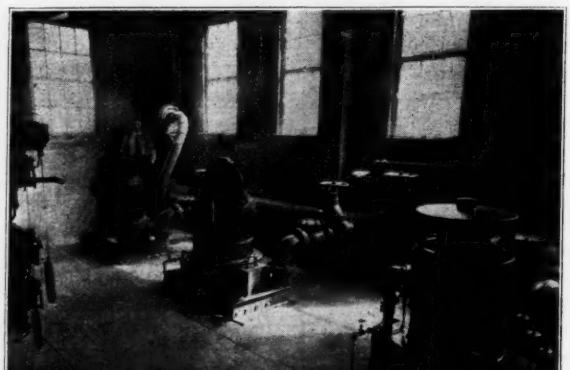
The integral governor with the directly connected flyballs mounted on the main shaft affords a compact, reliable governing mechanism. In this type of governor, the operating valve is mounted directly over the operating cylinder of the turbine, thus avoiding the long reaches of pipes which are necessary when the regulating valve is mounted on a stand on the generator floor. The advisability of avoiding gears and belts is again emphasized in the use of motor-driven flyballs. Load-limiting devices have been developed which provide an effective means of setting a definite limit to the power of the turbine as desired and at will. Devices have been installed on the governor whereby the moving of a switch at the switchboard will automatically close the turbine gates and apply the brakes, at the same time tripping the circuit breakers and the field switches on the main machine. This simple device has been found to be a great comfort to the operating staff, and security to the plants.

Automatic Stations

The automatic station, now a developed and assured type of installation, provides for the development of many low-head or small water-power projects which would not be economical if there had to be charged against its income the expense of the usual number of operators and attendants. The automatic station is usually within easy reaching distance of a "mother" station. It is amazing what these automatic features will accomplish in the way of starting the unit, synchronizing it, putting it on the line and putting it under load. There are also many protective features, consisting of devices that will shut down the unit in case of trash-racks clogging up, governor oil pressure becoming too low, hot bearings, too low or too high voltage, breaking of the governor belt, overspeed, or overload. While most of these functions are performed electrically, a number of them are accomplished by means of oil pressure. We may expect considerably greater development along this line.

Pump Installation Operates Automatically

SEVERAL UNUSUAL features characterize a sewage pumping station which is operated in the business district of San Francisco. The pumps, each capable of lifting 650 gal. per min., are electrically operated and automatically started and stopped. In connection with the automatic control, there is an electric alarm bell and



THIS SEWAGE PUMPING PLANT IS CONTROLLED AUTOMATICALLY

relay system which gives an alarm at the city corporation yard (where there is a man on duty at all times) should the pumps fail to keep the sewage down in the pump well. This is deemed especially desirable because of the damage that would be done to the goods in the basements of mercantile establishments whose sewage is handled by this station, should the sewage back up because of failure of the pumps to function.

IN MOST plants the motors are run from three-phase circuits, and the lighting supplied from the same source, but grouped on the different phases. It is necessary to choose the grouping and connection of lamps so that a reasonable balance will be maintained between phases. This involves dividing the lamps into three groups of equal probable use, which are sometimes inconvenient to connect. A more satisfactory arrangement may be secured by using three phase, two-phase transformation, dividing the lamps into two groups split between the two-phase secondary lines.

Lubrication of the Diesel Engine

SUCCESSFUL OPERATION DEPENDS UPON THE PROPER LUBRICANT BEING APPLIED AT THE RIGHT POINT AND BY THE RIGHT METHOD

PROBLEMS of lubrication are of great importance to the Diesel engineer. An engine may be declared a failure or a success depending entirely upon the selection of lubricants and the manner in which they are applied, therefore, if any feature of the lubrication method for a Diesel engine can be adjudged incorrect, the proper method should be sought out and put into immediate practice.

Parts to be lubricated on the power cylinder and piston are the cylinder wall, piston body and piston rings. A mechanical lubricator is particularly desirable for delivering oil under pressure at the right moment and to the right place, i. e., between the first and second piston rings when the piston is in its outward position. Large engines require the application of lubricating oil at more than two points in the power cylinder circumference and each point should preferably be supplied by an independent pump plunger.

OIL GOES TO CYLINDER AT THREE POINTS

Horizontal Diesel engines generally have three feeds to the power cylinder, one at the top and one at each side. Vertical Diesel engines are generally supplied with two or more suitably located oil feeds to each cylinder. Exhaust valve spindles and spindle guides require a small supply of lubricating oil regularly applied. This may be done by hand or drop feed method or by a mechanical lubricator, one point of application being sufficient to furnish lubrication. An over supply of oil will defeat lubrication by causing the formation of carbon deposit with the result that the valve action will be sluggish.

Piston pins are subjected to the following conditions: high temperature due to their enclosed location, poor radiation of heat, heavy pressure, as well as the slight pendulum motion of the connecting rod. Correct lubrication of this part is obtained by the use of pressure circulation. The crosshead is not subjected to high temperatures, it requires, however, careful attention because of the heavy pressure forces acting on the crosshead pin, the crosshead shoes and the crosshead guides. The method of application of the lubricating oil to crosshead guides is by means of a circulation system, drop feed oilers, or by mechanical force feed lubricator.

LUBRICATION OF AIR COMPRESSOR CYLINDERS

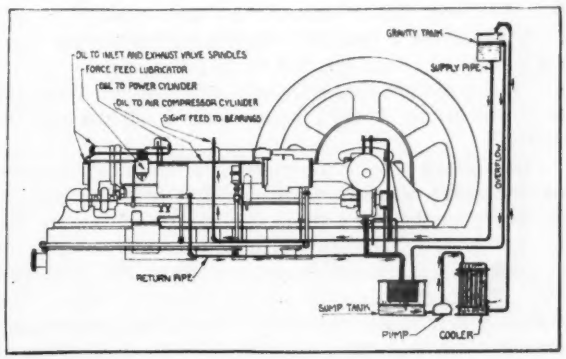
On air compressor cylinders and pistons, the surfaces to be lubricated are the cylinder walls, piston body and piston rings. The oil film besides eliminating metallic contact also acts as an oil seal, preventing air leakage past the piston.

Mechanical force feed lubricators are the usual means employed. Sometimes feeds are led to all of the cylinders, while in other cases one lead is used to the first stage only, this depends upon the size of the compressor and the thoroughness of distribution of the lubricating oil. The oil feed should be at a minimum rate, thus avoiding overfeeding, which is one of the greatest dangers in compressor operation. When lubricating oil is applied to the first-stage cylinder only, the air has to be depended upon to carry sufficient oil from the first-stage to lubricate the second and third-stage cylinders also. In large compressors, lubricating oil is fed to each cylinder, as the more positive method.

Bearings are usually supplied with automatic devices such as ring oilers, drop feed oilers, etc., and the helical gear that drives the cam shaft is lubricated by an oil splash system or from a direct supply of oil from the oil circulation system. Crankpins are lubricated by the oil circulation pressure or gravity system or by means of centrifugal oil rings which receive their oil supply from a gravity circulation system or a force feed mechanical lubricator. Main or crank shaft bearings are lubricated by a pressure circulation system, gravity circulation system, mechanical force feed lubricator, or ring oilers.

LUBRICATING OILS

With the continued use of the correct high-grade lubricating oils, as compared with inferior or incorrectly selected oils, the friction losses will be reduced, the cost of renewals and repairs minimized, and the certainty of



TYPICAL GRAVITY AND FORCED FEED LUBRICATION SYSTEM

operation greatly increased. There will be less likelihood of a breakdown, and the engine will have a longer life due to the more efficient lubrication. The necessity of using only the highest grade of lubricating oils, especially suitable for the operating conditions as they exist in a Diesel engine, has been strongly exemplified by the fact that most of the troubles experienced in the operation of Diesel engines have been found to be due, either directly or indirectly to the use of inferior or unsuitable lubricating oils.

In analyzing the lubrication requirements of Diesel engines, the parts to be lubricated fall into three groups, power cylinders, air compressor cylinders and bearings. The problem of efficient lubrication of the power cylinders of Diesel engines is the furnishing and maintaining of an oil film on the cylinder walls under the existing conditions of high pressure and high temperature, which result from the combustion of the fuel inside the cylinder.

High grade, straight mineral lubricating oil of correct body must be used for this purpose, which, in addition to preventing metallic contact between the piston rings and cylinder walls, furnishes a complete piston seal to prevent the blow-by of the gases of combustion and does not form excessive carbon deposits between and behind the piston rings. Oil too heavy in body does not flow easily, resulting in poor distribution. Oil too light in body does not maintain a complete oil film, resulting in metal to metal contact of the piston rings and cylinder walls. Blow-by of the gases of combustion past the piston takes place, further destroying the lubricating oil film and excessive wear follows. Oil of inferior quality will fail to furnish adequate

lubrication, as it will not withstand the conditions of high pressure and high temperature. It will "crack" in service leaving gummy deposits between and behind the piston rings causing these rings to stick and ultimately, in extreme cases, seizure of the piston may take place.

Air compressor cylinders and their lubrication requirements differ greatly from those in the power cylinders. The two main factors influencing the selection of the lubricating oil are the presence of moisture in the air compressor cylinder and the comparatively high temperature in the cylinder, due to compression of the air. The presence of moisture in the air compressor cylinders tends to destroy the lubricating oil film on the cylinder walls when a pure mineral oil is used. Rust formation and excessive wear follows, especially at the top part of the cylinder where lubrication is most needed, due to the extremely high pressure with which the piston rings are forced against the cylinder walls by the pressure of the compressed air behind the top piston rings.

To insure efficient lubrication of the air compressor cylinders, even under excessive moisture conditions, it is advisable to use a specially compounded high-grade lubricating oil. Such an oil, due to its lower surface tension, will make the oil film extremely adhesive and tenacious, thus preventing it from being washed off the cylinder walls.

In case the comparatively small valves and air passages become coated with an excessive amount of carbon deposits, especially in the third stage, the passage of the air may become greatly restricted, resulting in higher pressures and consequently higher temperatures of the discharged air. The carbon deposits may prevent the valves from closing properly, allowing a back flow of air into the compressor cylinders. For instance, a badly leaking third-stage suction valve or discharge valve may considerably increase the pressure, and consequently the temperature of the second stage discharge air to such an extent that the lubricating oil may be vaporized, the carbonized oil may become incandescent, more oil vapors will be generated and a mixture of oil vapor and air formed which may explode with disastrous results.

Selection of the correct oil for the lubrication of the bearings is also important. The conditions under which the bearing oils have to function are entirely different from the conditions found in the power and air compressor cylinders. High grade, straight mineral oil of the correct body must be used to form and maintain an efficient oil film between the journal and bearing surfaces. It must be especially manufactured to separate from water and other impurities which may enter the circulating system, and it must maintain its original characteristics under continuous service.

Oil too light in body will be unable to withstand the high pressure between the journal and bearing surfaces with the result that the oil film will break down, causing metal to metal contact. Oil too heavy in body will, because of the greatly increased fluid friction in the oil film, generate excessive heat, resulting in correspondingly high temperatures of the bearings. Oil of inferior quality, under these temperatures and the severe conditions in a circulation system, will finally break down and form an emulsion in the presence of water.

It is important that an oil in a circulation system, particularly in a small system where the oil is rapidly circulated, be kept free from impurities of all kinds, including water. The presence of water usually indicates leakage from the cooling apparatus. Sometimes this leakage is promptly detected but a small leak in an engine operating 24 hr. daily may not be noticed before the oil has been badly contaminated.

Some oils when subjected to rapid circulation through the system, especially in a small system, emulsify with the water and form an objectionable mixture which clogs the screens, forms a slime on the cooling coils and accumulates in the clearance spaces throughout the system. This mixture gradually becomes hard and in some instances causes a partial stoppage of the oil pipes. In such cases, the increasing temperature of the bearings indicates an insufficient oil supply and this condition demands an immediate shutdown to cleanse the system thoroughly.

Treatment of Oil in Circulation Systems

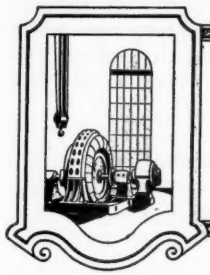
It is good practice to provide thermometers in the lubricating oil supply piping as well as in the return piping as a check on the working of the oil circulating system. The result of continuous use under extreme conditions is oxidation indicated by darkening color, slight acidity, increasing viscosity and gravity. The lubricating oil film on the power cylinder walls, being exposed to the products of combustion of the fuel oil will, of course, gradually become contaminated with carbon. Impurities such as incombustible matter, in the fuel oil or intake air, etc., adhering to the oil film on the cylinder walls, will contaminate this oil. This contaminated oil is continuously working its way downward and dropping off the ends of the cylinder walls and pistons. In those Diesel engines where the power cylinders are mounted directly on, and are in open communication with the crank case, this contaminated cylinder oil will drop into the crank case and foul the bearing oil.

Certain engines, especially those using the trunk type of piston, are often provided with oil trays below the cylinders which catch the lubricating oil dripping from the cylinder walls and pistons. These trays can be drained off separately, thus avoiding the contamination of the bearing oil in the crank case. In these engines, oil guards are usually fitted over the cranks in such a way as to prevent the bearing oil from being thrown by the cranks to the lower ends of the cylinder walls and pistons, thus preventing excessive lubrication of the power cylinders from this source and eliminating waste and carbonization of the bearing oil.

All circulation systems should contain a screen or strainer at the suction pipe to prevent the passage of comparatively large particles of foreign matter. In addition, a filter is advisable to take out the finer impurities from the oil which the screen does not remove.

It is advisable to remove a certain amount of oil, say 2 to 10 gal., dependent upon the size of the circulation system, each day and treat it in a separating tank which can be heated to remove carbon and other impurities. The purified oil can be returned to the system, with the necessary fresh make-up oil to replace the corresponding amount of oil taken out for treatment. Where the quantity of oil in use is small, this practice is particularly desirable for in this way the vitality of the oil is kept up to a high standard and its life greatly prolonged.

These important Diesel engine lubrication facts have been recently secured from the Vacuum Oil Co. and are embodied in a booklet entitled, "Stationary Diesel Engines and Their Lubrication."



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Notes on the design of Power Switchboards

SELECTION OF SWITCHBOARD EQUIPMENT DEPENDS LARGELY UPON LOCAL CONDITIONS AND SIZE OF PLANT. BY EMIL G. BERN*

IN ANY STATION the switchboard is a grouping of switches, instruments, and meters for the purpose of placing them within convenient reach of the attendant for manipulation, inspection and repair. On low voltage small capacity installations this is true to the full extent, while in the large power plants the switching equipment cannot be located in any one place but must necessarily be distributed over the entire station, and the best that can be attempted is a grouping of the indicating and control apparatus in a most convenient position. The design of the modern power plant switchboard centers about this point. The intention is to discuss here the problem from the point where the system of connection has been drawn and the equipment selected.

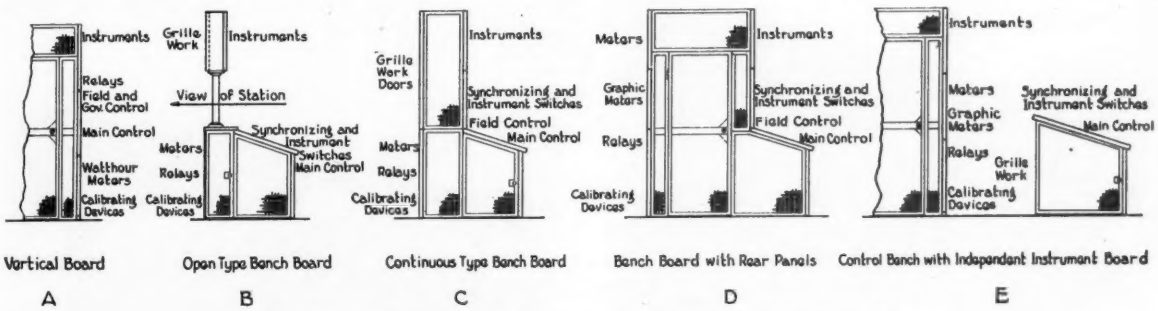


FIG. 1. REPRESENTATIVE TYPES OF POWER HOUSE SWITCHBOARDS

THE SIMPLE STATION

It is a curious fact that the largest power stations may sometimes have the simplest system of connection, which usually means also simple instrument and meter equipment. In such a case, the vertical 90-in. board can hardly be improved upon. Figure 1-A shows the logical arrangement of apparatus on such a board. See also Fig. 2. The control and instrument wiring is always brought to the board through floor conduits terminating a few inches back of the lower edge of the sub-base.

With this design of board the limitations lie mostly in the available display surface, which in height is limited by the convenience to the operator, and again by the reading range of the instruments from the operating positions. To compensate for this it is common practice to place some of the instruments on brackets, swinging or pivoted dependent on the conditions. Another method is to install the board in a broken or curved line, with the front side concave. Sometimes it is considered the lesser of several evils to complicate the instrument wiring by installing the meters, and perhaps even the relays, with their calibrating devices, on a separate auxiliary board, and thus relieve the operating board of that much equipment. A further advantage of this arrangement is that the meters can be read and the relays adjusted without interfering with the operator. Such a meter and relay board may be located back of the main board or facing it, but it is seldom advisable to place these devices on the back of the board.

GALLERY BOARD

It is frequently desirable, particularly in the medium size stations, to arrange the switchboard so that the attendant has a good view of the entire station. It is then customary to use what is commonly known as the open type benchboard shown in Fig. 1-B, installed on a gallery overlooking the machines. The distance between the back of this board and the gallery rail should be just sufficient for proper attention to relays and meters. This design embodies in one board the feature mentioned above, that meters and relays can be read and calibrated without interfering with the operator. The conduits can readily be accommodated in the gallery floor, as they are distributed in two rows. The instrument transformer leads come up back of the rear panels, through the calibrating devices, relays, meters, and instrument board columns to the instruments; while the control leads run up back of the subbases to the bench slab.

METHODS OF INCREASING THE DISPLAY SURFACE

Benchboards of the type illustrated in Fig. 1-C possess greater surface capacity than vertical boards, in three ways, viz.:

* Switchboard Engineering Department, General Electric Co., Schenectady, N. Y.

1. Greater height of surface for same vertical height, on account of the horizontal or slanting bench surface.
2. Permissible greater vertical height, and length of board, on account of operating position being farther from the instruments; i. e., more surface within the same angle of vision.
3. Addition of rear panels for meter, relay, and calibrating equipment.

Instrument and control leads are brought to the board in two rows same as with the open type board; from the relays and meters the transformer leads usually run overhead to the instruments.

The Complex Station

Meter and relay equipment with the associated calibrating devices frequently grow complex when connecting the big power stations with important transmission sys-

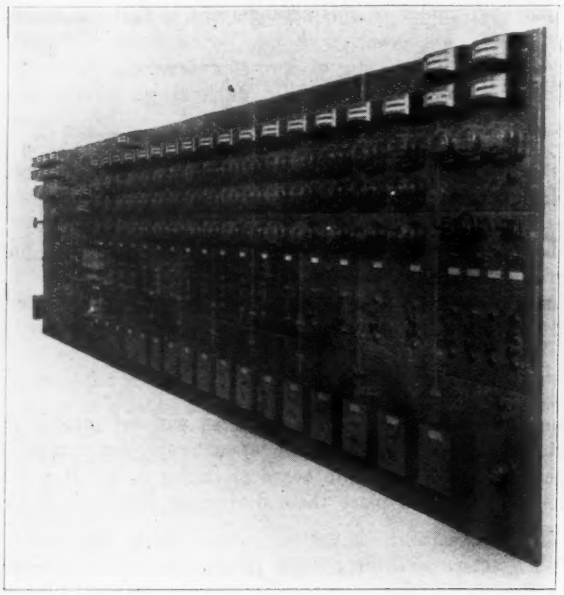


FIG. 2. VERTICAL CONTROL BOARD

tems; the instrument and control equipments also grow more complex and we are again facing the problem of finding more space within the same angle of vision of the operator. We can now separate the rear panels from the instrument and control board sufficiently to provide access to the interior through doors at ends of the structure, and make the rear panels the full height as shown in Fig. 1-D, and Fig. 3. This is usually found sufficient for any condition.

In Fig. 1-E is shown a type of construction with control bench and independent instrument board. This arrangement possesses the advantage of a further increase in display surface within the operator's angle of vision and permits an increase in height of the instrument board. Another feature of this design is that calibration is done facing the instruments, while not interfering with the operator; and the operator is well aware of what is going on during calibration, which is important should a mistake be made to cause an abnormal condition.

Occasionally the instrument board has been installed on a curved or broken line, concave to the control bench, and sometimes both are made in a concentric semi-circle with the operator's desk as the center.

Auxiliary Switchboards

The exciter board has no place in the switchboard room of a large power station. By this is meant the exciter and field switches with their busses, the field rheostats for the exciters and generators. All this equipment should be electrically operated, and located near the exciters to save cable runs. Control and instrument leads are easier to run great distances than main leads. In this manner, the instrument and control equipment for exciters and for generator fields can easily be accommodated on the main board in the most convenient positions. It may be needless to point out that the exciter board should be enclosed for protection but at the same time, not be forgotten in regard to cleaning and inspection.

Generator voltage regulator equipment is usually installed in the switchboard room, and may be located on the main board, or back of the operator, or perhaps at the side, dependent on local conditions. The same thing usually applies to the control battery equipment.

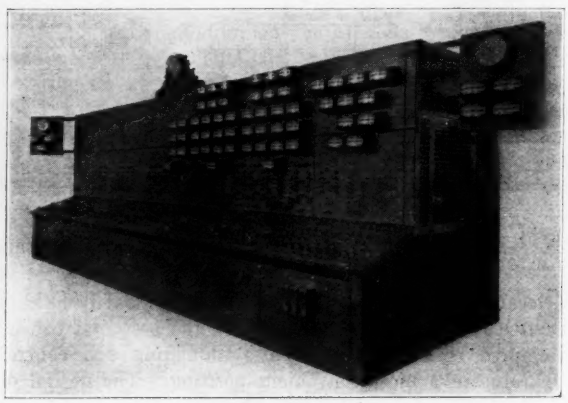


FIG. 3. BENCHBOARD FOR POWER HOUSE OF A LARGE TRANSMISSION SYSTEM

Station light and power board depends for its location on where it has been decided to place the responsibility for that service. The larger stations seldom burden their switchboard operators with this duty, and, therefore, this board is usually located elsewhere in the station. Taking it out of the hands of the switchboard operator calls for a safety enclosed board. For the circuits requiring oil circuit breakers truck panels offer many advantages.

General

Too much attention cannot be given to a logical arrangement of the equipment, with the aim of making the operator's work simpler and mistakes less liable to occur. The equipment most frequently used must be easiest accessible, and no piece of control apparatus so placed that its position renders it liable to accidental manipulation.

Having taken these things into account, the switchboard designer must not forget the esthetic side of his work, for the switchboard room is usually visited and criticized more than other parts of the station.

Variable Voltage Elevator Control Systems*

DETAILS OF A SYSTEM OF ELEVATOR CONTROL IN WHICH EACH ELEVATOR MOTOR IS SUPPLIED BY AN INDIVIDUAL GENERATOR. BY EDGAR M. BOUTON

LOW SPEED ELECTRIC elevators, using d. c. motors, came into use about 1890. Later, a. c. motors were employed, but on account of the difficulty of speed control could not be used for the high speeds necessary in tall buildings. Since the height of buildings is dependent upon the elevator system, and in many districts only a. c. is available, the need for high speed equipments that can be operated from a. c. is evident. A solution to the problem is found in the variable voltage system of control.

In this system each elevator motor is supplied by an individual generator driven by a motor operating from the a. c. or d. c. supply voltage. The generator's voltage, and hence the elevator motor's speed, are controlled by varying the field of the generator.

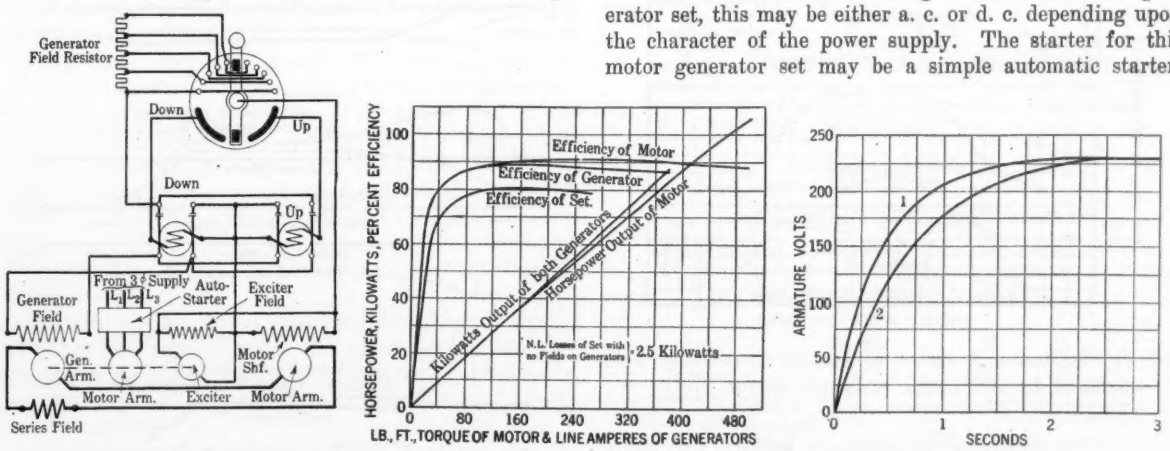


FIG. 1. DIAGRAM SHOWING PRINCIPAL CONNECTIONS OF SYSTEM. THE GENERATOR IS DRIVEN BY AN A. C. MOTOR AND HAS A DIRECT CONNECTED EXCITER. FIG 2. PERFORMANCE CURVES OF A DOUBLE GENERATOR-MOTOR GENERATOR SET WITH AN A. C. DRIVING MOTOR. FIG. 3. CURVES SHOWING THE RATE OF BUILDING UP OF GENERATOR VOLTAGE.

Apparatus used with this system consists of the following:

1. An ordinary shunt wound d. c. elevator motor.
2. A d. c. generator of special design for the elevator motor.
3. Control panel for the generator and elevator motor.
4. An a. c. or d. c. motor to drive the generator.
5. A starting device for the driving motor. And if the supply is a. c.
6. A direct connected exciter for the field and brake control circuits.

Figure 1 is a schematic diagram showing how the apparatus is connected.

With this system, the elevator motor requires no special features. It is a shunt wound machine which is the accepted type for elevator practice. The generator, however, is one of the most important units on the system and is designed almost entirely from the standpoint of its control functions. As shown in the schematic diagram the motor and generator armatures are connected directly together electrically without the use of any resistors. The direction of rotation and the speed at which the elevator motor runs depend upon the direction and value of the generator voltage. High efficiency and good voltage regulation are incorporated as essential features. Figure 2 shows the performance curves of a 25 kw. machine that are typical of what can be obtained.

Figure 3 shows a test on the rate of building up of a 25 kw. generator designed for variable voltage control service. Full excitation was thrown on the field coils in one step. The machine builds up to 85 per cent of its final voltage in 1¼ sec. and in 2½ sec. is generating full voltage. Curve 2 shows the effect of a short circuited damper winding on the field poles.

With reference to the driving motor of the motor generator set, this may be either a. c. or d. c. depending upon the character of the power supply. The starter for this motor generator set may be a simple automatic starter, since the sets are started infrequently and always start without load. Where d. c. motors are used, the only special feature required is a counter e. m. f. relay interlocking with the elevator controller to prevent energizing the generator field and brake circuits when the motor generator set is not running or before it has come up to speed.

ELEVATOR CONTROLLER

In the elevator controller are fitted the necessary contactors and relays to perform the following primary functions:

1. Connect the generator field to the excitation voltage in the proper direction for up or down motion of the car.
2. Energize the brake coil. The brake coil is opened on both sides and is fed through the same contactors that energize the generator field.
3. Control the car speed by controlling the excitation of the generator field.
4. Provide the proper discharge circuits for the generator field during retardation.
5. Connect in an extra demagnetizing field on the generator in stopping.
6. Open the connection between the generator and elevator motor after the car has come to rest.
7. Control the setting of the brake by means of its own self induction and so obtain a smooth stop.

*Abstract of a paper presented at the Midwinter Convention of the A. I. E. E. Philadelphia, Pa., Feb. 4-8, 1924.

Characteristics and Operation

To obtain maximum service from an elevator car, it should be accelerated and retarded at as high a rate as possible without discomfort to passengers. The uncomfortable feeling frequently experienced while riding in high speed elevators is not due to a high rate of acceleration but to rapid changes in the rate of acceleration. Therefore the rate of acceleration should not change suddenly during the accelerating period.

With variable voltage control it is possible to obtain uniform accelerating and retarding characteristics under widely varying load conditions. The generator voltage builds up uniformly, following a fixed law and the car speed follows the generator voltage. The torque developed

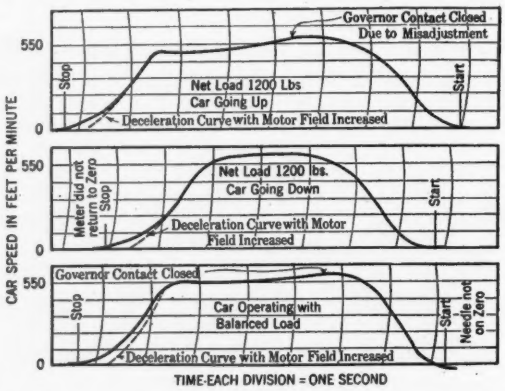


FIG. 4. OSCILLOGRAM SHOWING ARMATURE CURRENT AND CURRENT IN THE EXTRA STANDING MOTOR FIELDS

by the motor may be either positive or negative depending upon the load, but the speed in all cases depends upon the voltages generated by the machines.

If the car is to be stopped from high speed in a minimum of time, the maximum rate of retardation must be maintained during nearly the whole retarding period. When the controller handle is moved to the low-speed point resistance is connected in series and parallel with the generator field. The field shunt or discharge resistance can be adjusted if the generator field has the proper time constant, so as to give the car exactly the right rate of retardation. As the field dies down, the generator voltage falls below that of the elevator motor and regenerative braking brings the car to a low speed. The generator voltage falls with absolute smoothness and there are no steps as in the case of rheostatic control. The application of dynamic braking in steps produces peaks in the rate of retardation that tend to cause the cables to slip so that the average rate of retardation must be kept well below the peaks. The absence of these peaks makes it possible to keep the average rate of retardation very high.

Electrical or regenerative braking is used to bring the car to a very low speed from which the final stop can be made with a friction brake. The transition from electrical to friction braking is perfectly smooth as a result of the characteristics of the electrical system and the method of controlling the friction brake.

To avoid a jar when the final stop is made, there should be a smooth transition from the retardation produced by electrical braking to that developed by the friction brake. To accomplish this result, it is necessary to apply the friction brake gradually so that full braking torque is not exerted instantly. The brake must be designed and adjusted so as to stop the car smoothly both when stopping from full speed and when stopping from creeping speed.

When stopping from full speed, the brake should not set until the car has been slowed down to a low speed by electrical braking. When stopping from low speed, the brake should set in a very short time after the control handle is thrown to the off position but the torque should build up gradually so as not to produce a jar. The most practical means of controlling the setting of a d. c. brake

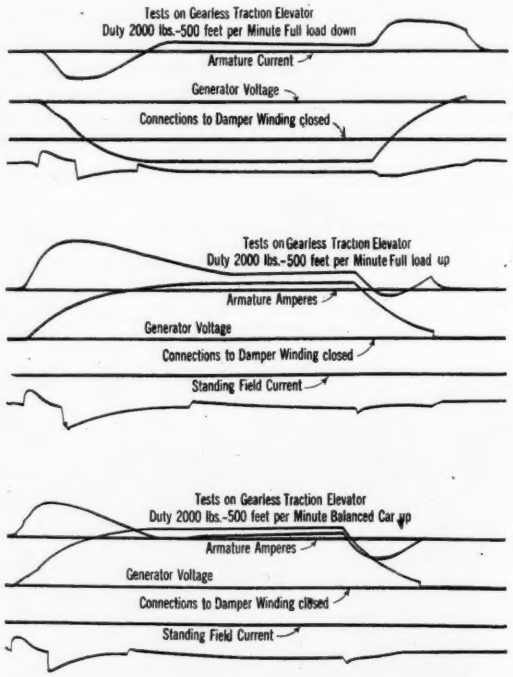

Tests on Gearless Traction Elevator
Duty 2000 lbs.-500 feet per Minute Full load down
Armature Current
Generator Voltage
Connections to Damper Winding closed
Tests on Gearless Traction Elevator
Duty 2000 lbs.-500 feet per Minute Full load up
Armature Amperes
Generator Voltage
Connections to Damper Winding closed
Standing Field Current
Tests on Gearless Traction Elevator
Duty 2000 lbs.-500 feet per Minute Balanced Car up
Armature Amperes
Generator Voltage
Connections to Damper Winding closed
Standing Field Current

FIG. 5. OSCILLOGRAM SHOWING ARMATURE CURRENT, GENERATOR VOLTAGE AND STANDING FIELD CURRENT

is to utilize the self induction of the brake coil in such a way that the flux is maintained in the magnet cores and retards or opposes the action of the brake spring in developing braking torque.

Tests were made on a gearless traction elevator rated 2000 lb. at 500 ft. per min., equipped with variable voltage control. The motor generator set consisted of an a. c. driving motor, a variable voltage generator, and a direct-connected exciter. The tests were made with the generator voltage adjusted to give a car speed of 550 ft. per min. with balanced load. The car was started by moving the master controller directly to the full-speed position in starting and stopped by moving directly to the off position. Figure 4 shows the speed-time curves obtained on these tests. The curves were drawn by a graphic meter which recorded the voltage generated by a magnet driven from the shaft of the elevator motor.

Figure 5 shows oscillograph records of armature current generator voltage, and current in the standing field of the motor. The motor also has an extra or starting field which is connected to the line for starting. This increases the total field during the first part of the accelerating period, giving a high starting torque. During the last part of the accelerating period, the generator field is over-

excited, in order to maintain a high rate of acceleration. The current in the standing field shows rapid changes in value, but due to its self inductance and to the mutual inductance between this field and the extra starting field the resultant change in flux is small and takes place quite slowly.

The retardation curves have the same general characteristics as the acceleration curves. The time required to stop from full speed is very nearly the same for all loads. In practise this uniform retardation under all load conditions makes it possible for car operators to gage the stops very accurately in stopping from high speed and so reduce the number of false stops and time lost in making landings. A dotted portion of the retardation curves is added to show the effect upon retardation of increasing the total field by the addition of the extra field.

Figure 6 shows the results of tests similar to those shown in Figs. 4 and 5 but made on a gearless traction elevator with rheostatic control. The curve of armature current shows notches as the steps of the starting resistance are short-circuited. These changes in the armature current correspond to changes in motor torque and in the rate of acceleration. The same notches are apparent as the dynamic braking resistance is short-circuited. These rapid changes in the rate of acceleration and retardation make it difficult to obtain smooth and comfortable operation. The speed time curves are less uniform than those shown in Fig. 4 and show more variation in time for different loads.

Experience has proved that variable voltage control is smoother in operation than the older system and that passengers can be handled more comfortably and quickly.

An analysis of the test data shows the following reasons for these results:

1. The rate of acceleration increases uniformly as the car comes up to speed and is not subject to rapid changes such as are produced by increasing the armature current in steps.
2. The time required to reach full speed is reduced.
3. The accelerating time and retardation time is constant for all conditions of load.

Regulation and Speed Control

In any elevator system, the speed at which the car may be run depends largely upon having a system of control that will give a positive low speed for making landings which does not fall off appreciably under load. With the variable voltage control system the speed regulation remains flat at as low as one-tenth full speed. Consequently it is easier to make an accurate landing, fewer false stops are made and the car may be "inched" easily and quickly. In stopping, regenerative braking is set up which brings the car quickly but smoothly to a low speed before the friction brake is applied. Positive speed control enables the limit stops to be made in less time and shorter distances without over travel.

Efficiency and Power Consumption

Factors affecting the power consumption of an elevator are so many and varied that it is extremely difficult to predict what it will be for a new installation. The more important factors are as follows:

(a) Load and speed.

(b) Number of stops and starts per mile of travel.

(c) Number of miles per hour that the car makes while in service.

(d) The weight of the moving masses that must be accelerated at each start.

(e) Method of operation.

With the variable voltage control system less power is required in acceleration and retardation than with the rheostatic system. This saving in power over the rheostatic control is greatest when the number of starts and stops is large. Power is returned to the line while making the limit stops. Power consumption is not increased in making small movements of the car or in running at low speed.

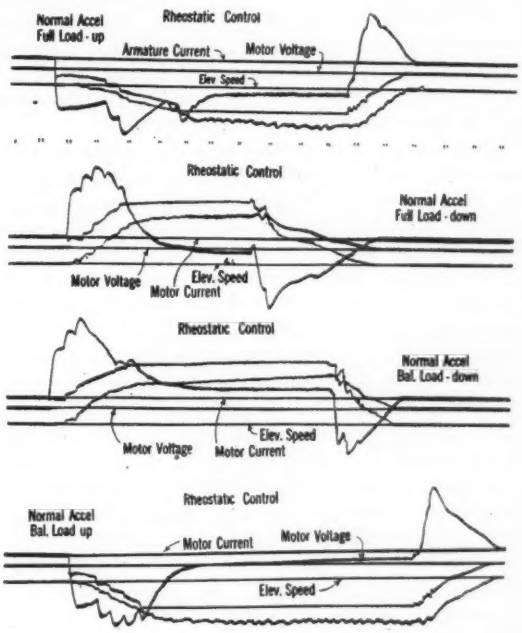


FIG. 6. ACCELERATING CHARACTERISTICS OF A GEARLESS TRACTION ELEVATOR WITH RHEOSTATIC CONTROL

During idle periods standby losses may be eliminated by shutting down the motor generator set.

Safety Features

An elevator control system should be so designed that the car will be slowed down and finally stopped as it approaches the terminal landings. In order to be sure that the car platform will come flush with the top and bottom landings under all conditions of load, the stop contact on the slow-down device must not open until the car has reached the floor level. It is preferable that the point of cut-off be a few inches beyond the floor level so that the operator will not form the habit of depending entirely upon the automatic device for making the stop. It is necessary then, when the car reaches the cut-off point, that it be slowed down to a low enough speed so as not to drift further than the distance provided for over travel. If the car runs by the over-travel limit switch it is not possible, with the usual connections, to back out and the assistance of an attendant is necessary to put the car into service again. To stop a fully loaded car within the usual over-travel distance has always been a considerable problem with rheostatic control because of the extremely poor regulation of the motor when operating at reduced speed with armature series and shunt resistance.

A switch is mounted on the car having contacts actuated by an arm and roller which engages a cam in the

elevator shaft. As the car approaches the top and bottom landings these contacts operate to insert steps of resistance in the generator field, in the variable voltage system, which reduces the voltage. The car speed reduces with the reduction of voltage due to the regenerative braking that takes place until, as the landing is approached, the car is running at very low speed.

The inherent regulation of the variable voltage system makes it possible to slow down a fully loaded car in almost the same distance as an empty car. It is possible to stop the car at the terminal landings under all conditions of load within 1 in. of the same spot. The positive action of the automatic slowdown at the limits of travel greatly increases the safety of operation. The automatic slowdown and stop at the terminal landings is one of the elements in the system of safety devices provided for the elevator and it is important that it functions properly.

When making normal stops with the regular controlling means such as the car master switch or the automatic limit stops, the generator field is reduced to zero which sets up regenerative braking in the elevator motor which slows it down. At the same time the friction brake sets which brings the car to rest. To provide against failure of the master switch contacts to function or a failure of the regular stopping cycle the car is equipped with the usual emergency switch. This switch opens the armature circuit contactor which disconnects the elevator motor entirely from the generator and connects it to a low-resistance dynamic braking circuit. The coils to the brake contactors are opened and the brake circuit itself is also opened by auxiliary contacts on the armature contactor. This arrangement gives two entirely independent means of stopping the car and is an advantage over the older forms of control in which the emergency switch forms only an additional means of opening the same contactors that disconnect the motor in regular operation.

The failure of the main power supply on a large system is a comparatively rare occurrence, but failure of power from some cause to elevator motors has been a rather frequent source of trouble. Failure of power to an elevator may be due to (1) failure of the main power supply to the building, (2) the opening of the main circuit breaker in the building, (3) opening of the circuit breaker or blowing a fuse in the line feeding the elevator. I shall analyze the result of a power failure under several conditions and discuss means for taking care of the condition.

When the motor is operating under positive load, that is when hoisting an unbalanced load, there is no particular danger from power failure as the car will stop of its own accord in a comparatively short distance. The condition of balanced or overhauling load presents a more serious problem. Let us consider first the case of overhauling load produced by a fully loaded car going down. Consider first the case of a d. c. motor controlled by armature series and shunt resistance and motor field control. With overhauling load the motor is operating as a generator and returning power to the line and is kept at constant speed by the supply voltage. The contactor magnets on the controller are energized from the supply voltage. If now the power source is cut off by an opening of the circuit breaker in the line to the motor, the reservoir into which the motor has been delivering its power will have been disconnected and the motor and car will overspeed. There will be no warning to the operator that the power has failed until the car has reached a considerable overspeed, probably high enough to trip the safety clamps under the car. The control magnets will be kept energized by the voltage generated in the armature of the elevator motor so that the dynamic braking circuits will not be set up or the friction brake disconnected until the overspeed governor driven by the car has opened its contacts. In other words, there is nothing to start the functioning of the control to stop the car until there has been an actual overspeeding of the car.

Consider next the case of an elevator motor driven through a motor generator set with an a. c. driving motor and having either one or two generators. The motor generator set comprises a small direct-connected, self-excited generator to furnish d. c. excitation to the generator and motor fields, brake and control circuits. In case of overhauling load the elevator motor is acting as a generator, the generator end of the motor generator set is acting as a motor, the motor of the set acts as an induction generator and is running above synchronous speed. It should be kept in mind that the elevator motor is generating a voltage higher than its terminal voltage due to the drop in the windings. For the same reason the generator, acting now as a motor, is generating a counter voltage lower than its terminal voltage by the value of its internal drops.

When the circuit breaker opens the energy that is being developed by the descending car is expended in accelerating the motor generator set which speeds up until the generator voltage equals the voltage generated by the elevator motor, the internal drops reducing to a very low value. The result will be an overspeed on the set of 15 or 20 per cent above synchronous speed. The motor generator set is equipped with an overspeed device which opens a contact in the safety circuit of the elevator controller that sets the friction brake and sets up the emergency dynamic braking circuit. The motor generator set is now running free at overspeed and due to its inertia runs for several seconds before the direct-connected exciter loses its voltage. The field of the elevator motor is connected directly to the exciter so that a strong field is maintained for dynamic braking long enough to bring the car completely to rest before the exciter loses its voltage. The same cycle is perfomed when the driving motor of the set is a d. c. machine. The only difference is in the connections of the field of the elevator motor which are such that the counter e. m. f. of the driving motor maintains the excitation on the elevator motor field. Tests have shown that the car is stopped promptly and without over travel when a power failure occurs while making the limit stops.

To DETERMINE THE LOCATION of a "short" in the field coil of a motor or generator the best method is to use a voltmeter and measure the drop across each coil. If one coil is defective the drop across the defective coil will be less than that across the others. If none of the coils are shortened or otherwise defective, the drop across each coil will be equal to the line voltage divided by the number of field coils, that is, if they are connected in series. If a voltmeter is not available a lamp may be used although this is not quite as satisfactory. When the lamp is used the defective coil will be indicated by the decreased brightness.

Another method of locating shorts in field coils is to connect the field circuit directly across a line of normal voltage. The current is allowed to remain on for about 20 minutes, after which any defective coils may be noted by their different temperatures.

Electrical Distribution Systems in Europe

NOTES FROM AN ADDRESS DELIVERED BEFORE THE WESTERN SOCIETY OF ENGINEERS. BY B. G. JAMIESON*

BEFORE GIVING an account of my impressions regarding the electrical distribution situation in Europe, it may be well to present a brief outline of our trip. Our party who represented the Insull interests or rather the combined nearby interests consisted of five men, Messrs. Denny W. Roper, Samuel Insull, Jr., Secor Cunningham, Jr., Frank E. Goodnow, and the writer. Starting from London on the 29th of June, we went up to Birmingham, which was a sort of a by-trip, and from there proceeded to Newcastle, where we visited the stations of the Newcastle Electricity Supply System and the Parsons Works. From there, we went to Glasgow, back through Liverpool, Manchester, Stratford and down to London. That trip took nearly a month, and it involved visits to several distribution systems, several apparatus and cable factories and also to some laboratories.

Leaving London about the 20th of July, we went to Paris and from there down through Belfort, Zurich, and Berne, to Milan, which we made our headquarters for a while. Leaving Italy, the trip took us to Barcelona, up through France, Belgium, and Holland and finally to Germany, arriving in Berlin on Aug. 7. From there to Sweden and Norway and back across the North Sea to England.

Now the first question that may arise in discussing European conditions with one who has made a trip such as we took is this: "Are they ahead of us?

This, to say the least, is a difficult question to answer. There are so many things in Europe which are, temporarily, at least, depressed by the great struggle so recently terminated that it is extremely difficult to measure in words the exact status, particularly of the electrical supply and distribution systems. A factor in any sort of verdict in that matter is one which I think would influence or impress anyone who had been over on a similar trip; that is the difficulty of arriving at a sort of mental average of the impressions which one receives from an extensive trip of that sort.

Figure 1 shows the route which was covered. The approximate mileage was 17,000 and we visited 50 stations, about half of which were steam and half hydroelectric.

NATIONAL ELECTRIFICATION HAS MADE GREAT HEADWAY

Perhaps the most outstanding feature regarding the electrical situation in Europe, to impress the American engineer is the great progress in national electrification. By this I mean, electrification by decree. Whether it is economical or not, in the long run and considered from the standpoint of safeguarding the nation's commercial interests, remains to be seen, but on the Continent it has resulted in a great measure of development and progress in the construction of central stations.

VOLTAGE OF SYSTEMS

There is another elusive factor which I have been wrestling with ever since I got back, and which I hesitate to state, which is, to me, a gage of European practice and it is difficult to say whether the impression that I got in this particular is correct or not. I refer to the voltages of the systems which are used in the distribution of electricity. Certainly we don't find as high a voltage there as you find in this country but that alone isn't the measure of progress insofar as transmitting energy is concerned. The point which seems to me to define progress in operation at higher voltage, is the relation between the voltage employed and the amount of energy delivered over given districts, independent of the factor of distance which necessitates extremely high voltages in some cases.

To make that a little plainer, if a company has to deliver energy at a distance of two or three hundred miles the voltage, of course, must go, because of the dictates of economy, to two or three hundred thousand volts. On the other hand if it has to transmit only 10 mi. and 10,000 v.

FIG. 1. MAP SHOWING ROUTE COVERED ON TRIP

would be sufficiently high to balance the investment, and it is using 40,000 v. for the purpose, and if its receivers, which are commonly in this country 110 and 220 v. are all 440, then the average voltage that the company is using is higher than is the practice commonly.

In Europe it is common in the distribution systems to find 380 and 400 delta voltage and 400 v. and 440 are quite common in direct current, allowing the utilization of 220-v. lamps.

With regard to the poorer voltage and frequency regulation, I don't know whether it is due to the fact that the government owns so much of the continental development but seemingly they are paying much less attention to regulation than is common here.

There is another feature of considerable interest in Europe which has to do with the energy output per pound of material, particularly in generators. Due to the fact that 50 cycles is common, it is possible that the claims made, particularly in England, are quite well founded. The claim is simply this, that with their 3000-r.p.m. prime movers they are able to get some 60, and they say 70 per

* Engineer of Inside Plant, Commonwealth Edison Co., Chicago.

cent, more work out of a pound of material than we do. That is quite an increase if it is true. You understand, of course, that the 60 cycles limits the American to 1800 r.p.m. in the large machines and unless he splits them up into a number of small machines he cannot make the step from 1800 to 3600, while the European, who has the 50 cycles, can build a 3000-r.p.m. machine and seems to be doing it successfully.

Segregated D. C. Networks

As a matter of fact, over there, instead of one large network, where there are any direct current networks they are split up and supplied from substations with only a light, inconsequential bonding between the several sections, —instead of operating large interconnected networks that characterize the large cities of this country, such as New York, Boston, and Chicago.

FIG. 2. TROLLHATTAN HYDROELECTRIC STATION, SWEDEN

Current limiting reactors are not widely used, due partly to the success of the underground cable.

Wide Use of Shaft Exciters

One thing that was very funny to me was the universal employment of shaft exciters,—that seemed very funny to me because of the serious consideration of the question here some two or three years ago as to whether it was practical or not to operate shaft exciters. The same question came up again not long ago, when it was felt that we might want to put auxiliary exciters on the shafts of large prime movers. Yet over in Europe you will find exciters shaft driven almost universally.

Static condensers have been successfully developed in Europe. That is of particular interest, because of the dubiousness of the American manufacturers. The Helsby condenser is used rather widely in England and on the Continent. In Belgium, there was a rather active agency advertising them for power factor correction. The Helsby condenser is either successful or else the statistics which they give out are much in error. The condenser unit is a very small device, one-half kv.a. capacity of the roll type, with a 600-v. dielectric voltage, and a test voltage of 2400. An explanation as given me by an American manufacturer in regard to the English claims of non-failure was to this effect: "Well, the condensers do fail. But when the insulation fails it immediately heals." Now, if a condenser or cable punctures and immediately heals itself, and there is no resulting disturbance, I think that the term failure is at least debatable.

Induction motors with reduced starting current have also been applied successfully and the Erlicon company has been operating with a motor that is, so far as we know, a duplicate of the Fynn-Weischel motor now being advertised by the Wagner people. At the meeting in Omaha where the representative of the Wagner people made his opening talk on this power factor correcting motor, I asked directly the question, what was the difference between the Fynn-Weischel and the Erlicon motor, that is, the combination synchronous induction motor and he said, "I don't know. We are getting one over here to find out."

Motors, with reduced starting current are built quite commonly in Europe and I understand they have been built in this country for some purposes but they haven't been used on our larger systems very generally. I refer to motors with split windings, which give very low starting current.

Oil Circuit Breaker Research in England

Germany was foremost in all of the research work back of oil breaker development before the World War began. Then the Swiss firm, Brown Boveri, took up the work. It

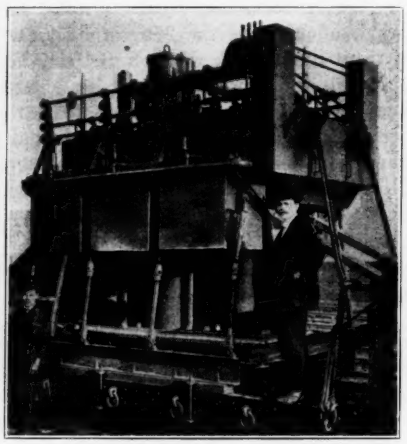


FIG. 3. LARGE ENGLISH CIRCUIT BREAKER MOUNTED ON RAILWAY TRUCK

was taken up in a thorough manner and what is more all their findings were published in English as well as in other languages. The work they did is very creditable indeed. Continental breakers differ from English breakers in one respect. It is the aim of the Continental manufacturers, notably the German and the Swiss, to produce a device which, with certain essential appurtenances, will take care of the problem of interrupting of electrical energy in oil without resorting to a development which necessitates greatly increased overall size and strength. They use resistances, they use multi-breakers and various devices in an effort to keep down the size and cost.

Some exceptionally high-speed air breakers have been produced in England, and one breaker we saw, particularly impressed us. A resistance is used, however, in the intermediate stage in the interruption. The speed of this breaker from rest to rest is within the time of the fastest type of American breakers. We have 0.008 sec. for some service in this country and we think that is rapid, but when we were told that this breaker operated in 0.004 we didn't believe it, until we were shown some oscillograms that confirmed it. This breaker operates so rapidly that on short circuit 50 cycles it gets out before the normal crest of the wave would be reached. The breaker is built, I believe,

up to capacities of 2000 amp., and for pressures up to 1500 v.

Referring to the armored gear of England it seems to me that "armor" is somewhat a misleading term, as the armor is principally on the busses and other appurtenances and it does not add materially to the strength of the breaker proper.

You will find in the literature concerning these breakers estimates of the necessity of taking care of something like 1000 lb. to the square inch, and you saw on the slide which I showed you, a formidable device which looks like a very strong switch—and it is strong. Moreover, I will tell you something which will give you an idea, perhaps, of how strong a breaker would have to be designed along the lines of taking care of ultimate stresses developed without attempting to prevent them.

I saw a 5/8-in. steel plate with a circular shear in the middle of it which it was calculated required over 10,000 lb. per sq. in. to produce. That was caused by a short circuit in a breaker. Now if pressures of that magnitude

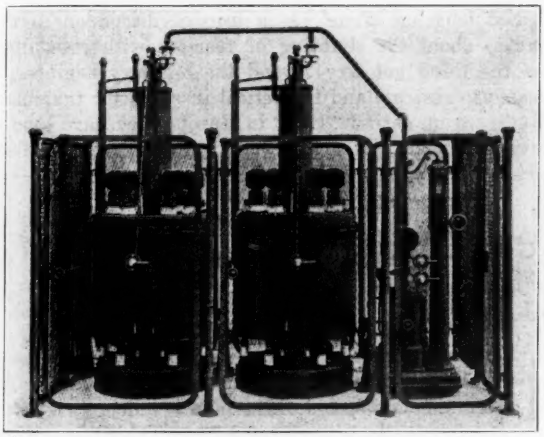


FIG. 4. ONE OF 16 GROUPS OF 1200-KW., 1575-V. MERCURY ARC RECTIFIERS USED ON THE MIDI RAILWAY IN FRANCE

are to be handled, when energies on the order of a million and a half to two million kv.a. are to be handled, we are certainly in for some very expensive construction and apparatus, unless methods are devised to reduce these liabilities either in the breaker or in the systems served.

There is under way in England at Newcastle one of the most comprehensive and intensive studies of the phenomena of arc breaking in oil ever conducted, and they are going right down to the fundamentals of the problem. The apparatus used is basic, refined, and extremely comprehensive. All the essentials of circuit breaker performance, such as the effect of length of break, the strength of springs, speed of the breaking parts, the head of oil, the timing devices that put the short circuit on and re-establish it at the same point of the wave on succeeding short circuits, three part oscillographs movie cameras and all other equipment are available for these tests. It is being conducted under the auspices of the government, the British Institute, and the educational institutions.

General Aspect of European Stations

European power stations in general, particularly those in the water power districts, are quite different from many of those that you see in this country, which gradually become crowded as the development occurs. I saw a cut here the other day of a new station designed for 15 or 16 units ultimately. The picture would remind one of the old advertisements of factories. In the case of a station planned for so many units, with the rapidly changing art, what happens is that the station goes a little way along the original line and then everything changes.

In Sweden the distribution centers are growing in size. In a small place like Stockholm, for instance, where perhaps there will never be a commercial load of more than 200,000 kw. unless something very unusual happens, 40,000 kw. substations are planned.

Mercury Arc Rectifiers

Mercury arc rectifiers are utilized in Europe to a considerable extent. They have been the subject of discussion for years as to their practicability. Rectifiers have been in

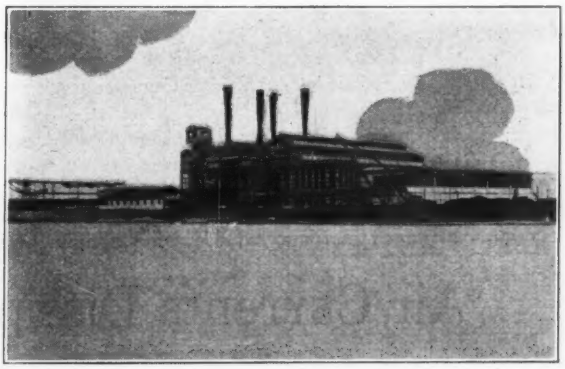


FIG. 5. GENNEVILLIERS STATION, PARIS, FRANCE

use for about ten years, about 105,000 kw. of capacity in a total of about 400 tanks being in use today. The voltages range from something in the vicinity of 400 up to 1500, and the Brown Boveri Co. of Switzerland express a willingness to build rectifiers for 3000 v. In fact, their English agents have advertised rectifiers up to 6000 v. d.c. Perhaps that is a rather safe advertisement since, as I understand it, nobody wants 6000 v. The Brown Boveri Co., which is a rather cautious and conservative firm, however, seems quite satisfied that 3000 v. is quite practical.

In some cases rectifiers are operating in parallel with the converters. That was said to be one of the impractical things. The rectifiers take the fluctuating load and where anything in the nature of regenerative character is required converters are used.

Figure 4 is a view of a commercial type rectifier used on the Midi system in France. It is rated as 1200 kw., 1575 v., and is one of 16 groups. The 16 groups of rectifiers aggregate about 19,000 kw. If the Midi system is wrong in using rectifiers, they have made an awful mistake.

The P. & O. people are preparing to electrify their system, and would not even consider rectifiers. More than that, they will not even give you an answer as to why they didn't consider them. It is apparent, therefore, that there is a little diversity in the opinion of the practicability of rectifiers at this time, even after 10 yr. of demonstration. The Brown Boveri people, who build the Champion rectifiers since Germany has been obscured, claim that without question they have overcome some of the fundamental objections and supposed shortcomings of rectifiers. They have

made an absolute seal; that is to say, the vacuum is held at 0.01 mm. of mercury, it must be maintained at that figure to avoid excessive pumping, and to avoid sustained shut-downs after flash-overs. They have, by their mercury seal around these anodes, absolutely overcome the fault of leakage, so they say. They have experimented with their anode construction until they have been able to procure unfailingly a type of iron for their anodes which seems to be free to a great extent from the objection which characterized so much of the earlier rectifier construction, namely, the emission of gases from the anode which contaminated and destroyed the vacuum. The action of rectifiers is simple. It is absolutely noiseless and there is no question of ventilation. It should present almost a minimum in installation cost. It is efficient on low loads and requires no particularly favorable ambient conditions. The consumption of water for the cooling of the anodes and the mercury cathode is extremely low, something around 5 g.p.m. perhaps, as a maximum, for the largest double tank.

Direct Current Transmission

In France the Thury system has been operating successfully for some years 100,000 v. direct current. The arrangement for getting that voltage has been awkward, consisting of a pyramided group of generators in successive steps of 20,000 v. approximately and then taking off the energy at receiving stations by means of a cascade of motor generators arranged in somewhat the same fashion. Despite the somewhat cumbersome arrangement, the system has been operating for many years and plans are now under way to change it to 300,000 v. direct current, underground.

Now, when you consider France with its troubles in the World War, and the trouble she is having now, and the fact that she has not had available the power tubes, which are apparently a better means of producing high voltage direct current, it seems that France, at least, has wisely anticipated the possibilities of some device of that character. I suppose all engineers will agree that direct current, high voltage transmission is superior to a.c. current, underground, when voltages of between 100,000, 200,000, and 300,000 and that vicinity are contemplated.

While there is the usual divergence of engineering opinion over there some features comparatively new in this country are an old story in Europe; for instance, the use of conservators on transformers is an old practice over there. On the other hand, internally water-cooled transformers are rare,—forced oil circulation being almost universal.

Not long ago there was a spirited discussion in this country about the shunting of reactors with resistances, and the thing got way beyond the ordinary engineer, it became so abstruse and theoretical in character that many of us gave up entirely. But in Europe they have been in service for years. A small 1200-v. railway with a 1200-v. storage battery was also a feature of interest.

Air Currents Dissipate Generator Losses

Effectiveness of Ventilation is a Factor in Limiting Capacity and Efficiency of Generators. By Arthur L. Greene

BUILDING efficient and dependable hydroelectric plants has included from the very beginning of modern developments the study of proper means for eliminating heat units in the average central station equipment. Ventilation and cleanliness have attained such importance in the analysis of central station efficiency that these now rank second to none as prime factors making for capacity or under-capacity operation of a plant, depending on how well these problems are met and overcome.

One of the fundamental rules long associated with efficient operation is that the capacity of the generator unit is directly dependent on the air conditions, or, to be more specific, the capacity of a generator is always dependent on the temperature of its windings. This is so because every generator is designed to carry a given load with a certain maximum temperature in the armature and field windings. This temperature must naturally be well within the critical temperature of the insulation, and exactly as the temperature is reduced, so in exact ratio does the load increase which it can carry with safety. In connection with this latter, it must be remembered that generators reach their maximum efficiency at or above full load. The output of a generator, for instance, receiving air at 77 deg. F. is 18 per cent greater than with air at 100 deg. F.

We are accustomed to think of air as the cheapest thing in the world. An investigation of the results attained, using air in generator cooling, would tend to discredit this popular belief. It is true that large volumes can be handled at a remarkably low price. It oftentimes happens, also, that openings create a natural draft of cool air; when this occurs, it may obviate the necessity for a mechanical apparatus. A report recently issued by the National Electric Light Association of New York brings out the interesting fact, however, that we are not so fortunate in the low specific heat of air which at constant pressure is usually given at 0.2375. "This," states the report, "coupled with the specific weight of 0.075 lb. at 65 deg. F. requires the use of a large volume of air to absorb a small quantity of heat. In fact, 56 cu. ft. heated through 1 deg. F. are necessary to absorb 1 B.t.u. In addition air supports combustion, which makes it undesirable from an electrical standpoint. Still air is an excellent non-conductor of heat, and to be effective for cooling the air must be kept in motion. Most unfortunate for its use with electrical apparatus is the solid matter that it carries in suspension. In spite of its many drawbacks there appears at present no simpler or more economical method of cooling much electrical apparatus than by the use of air.

"Because it requires 56 cu. ft. heated through 1 deg. F., to absorb 1 B.t.u., the volume of air necessary to cool a large generator becomes enormous and may, in 30 or 40 min. amount to a weight equal to that of the generator itself and more than the weight of steam supplied to the turbine to drive the generator. To move such a weight at velocities from 1000 ft. per min. to more than a mile a minute requires the expenditure of considerable power."

In the early days, of course, machines were of small size and generally of slow speed as compared with those of the present. In consequence there was little trouble or annoyance experienced from such items as noise, unclean air, overheating, etc. With the introduction of the present day machine developing thousands of horsepower, of great size and weight, rotating at immense speed and with

its location oftentimes in dust laden places, it has been necessary at times to enclose or partially enclose these types. Accompanying the necessity for enclosure has followed that of supplying a forced draft to exhaust the heated air from the armature windings and to induce a draft of clean, outside air.

Experiment has shown, however, that there is a definite limit beyond which it is impracticable to use a totally enclosed motor. It is obvious, of course, that the slow speed motor is best adapted to enclosure. Some experiments have been carried on along the lines of increasing the heat diffusing surface of a motor through the aid of ribs and brackets. But this has been found uneconomical because of the increased cost and the awkward construction necessary. For all practical purposes it may be said that experiments of late years have been concentrated almost entirely in dissipating the heat generated by means of passing or drawing air at high velocity through the generator windings.

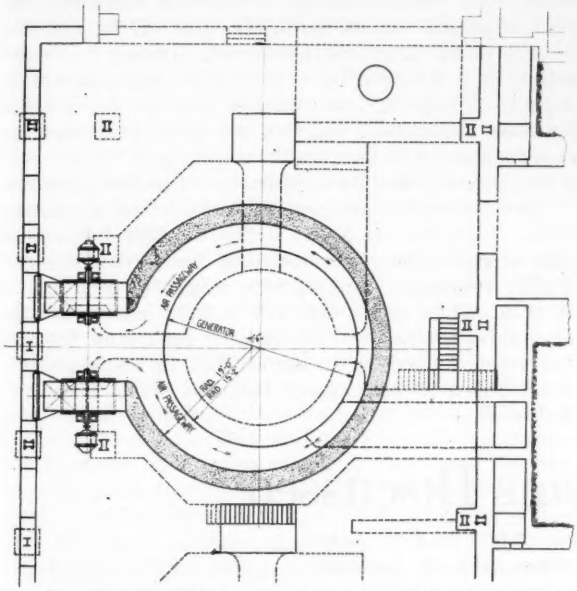


FIG. 1. HOUSING FORMS ON AIR PASSAGEWAY COMPLETELY AROUND 70,000-HP. GENERATOR AT NIAGARA PLANT

This is generally accomplished by one of two methods or a combination of both. Either a fan may be connected direct to the rotor which will force the air through the armature windings, a fan may be connected by means of a duct to the generator casing, in which case the air is drawn through the windings and exhausted outside, or both these methods may be employed together when a large unit is used and where the volume of air to be exhausted is of great proportions. It is the generally accepted standard to figure from 80 to 100 cu. ft. per min. per kilowatt loss; the former figure being specified for the higher speed turbines while the latter amount is generally applicable to the lower speed units. The amount of air necessary, is, of course, directly dependent on the temperature rise; the greater the amount of air circulated, the lower being the rise in temperature for a given period. Greatest efficiency is obtained by having as short inlet and outlet ducts as possible, and elimination of all unnecessary bends and turns in the air passageways.

In the case of a turbine or generator set installed where there is a considerable amount of dirt, loose particles of solid matter, oil, humidity, etc., it is the custom to install with the fan a system for cleaning and cooling the air before it passes through the armature windings. This can be done either by means of an open air washer type which takes the air from the outside, passes it through a water spray—(such as employed with the Carrier air washer)—thereby eliminating all impurities in the air and cooling the air at the same time—thence through the generator. The exhaust is generally through openings in the top of the

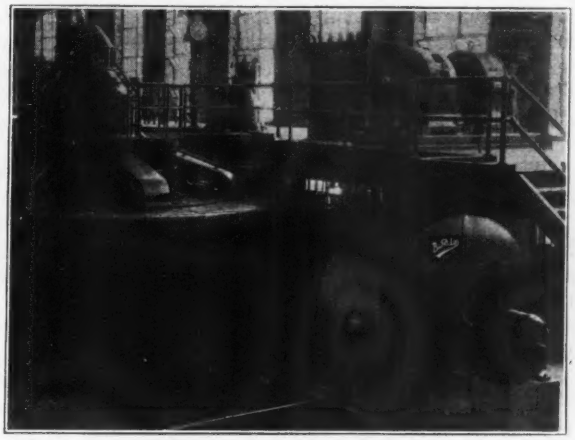


FIG. 2. TWO OF THESE FANS ARE REQUIRED TO VENTILATE EACH HYDROELECTRIC GENERATOR IN NIAGARA PLANT

generator and up through vent openings in the roof of the building. Another method is to use a closed type of apparatus, which recirculates entirely and takes no outside air at all, either from the room in which the generator is located or from outside. With this system, the air passes through the generator, over some water coils which cool the hot air and then recirculates through the generator again. This is a continuous process.

Ventilation of electrical equipment is generally divided into two systems—direct and indirect. In the former, the air is forced directly through the machine, and by contact with the radiating surfaces of the machine, the heat is absorbed by the passing air. In the latter, or indirect method, reference is made to cooling the rooms themselves. such as the rotary rooms. This is properly called indirect ventilation because the machine radiates its heat to the surrounding air, and this air is then removed and replaced by outside air. This indirect method is not generally applicable to large installations or where there is any considerable amount of impurities in the air.

Greatest troubles experienced with generator operation, such as the field winding breaking down, are usually associated with the location of a generator unit where metallic dust exists. General rules, however, governing the type ventilating equipment to be used are difficult to state, and are for the most part of little or no help, because every installation offers its own particular problem to the engineer.

Perhaps greatest interest centers at this time in the equipment being installed in the new power station being added to the lower river station of the Niagara Power Co. of Niagara Falls, and designated as Station 3-C. We will only mention in brief the major features of this new hydraulic station in order to give a perspective in connection with the ventilating equipment being installed.

This new station, which will create a new standard in

the hydroelectric field when completed, will consist of three units, each of the vertical shaft type and having self excited generators set directly above the generators. Each turbine is rated at 70,000 hp. under a net head of 213 ft. The generators are rated at 65,000 kv.a. each, of 12,000 v., 3-phase, 25-cycle, 107.14 r.p.m. These generators are of the internal revolving field type, with overhead Kingsbury thrust bearings, and a single guide bearing located immediately below the thrust. The second guide bearing is provided by the turbine. The generator rotor weighs 399 T., while each machine in its entirety weighs approximately 755 T. The maximum shaft diameter is 34 in. A service generator of 650 kv.a., capacity at 2200 v., is built into each machine for the purpose of supplying the unit auxiliaries, such as motor driven exciter, governor pumps, ventilating fans, etc.

When this new station is in operation, which will probably be sometime this spring, there will be installed under one roof, units with a total combined capacity of 454,500 hp. Some idea of the power generated is had when it is stated that this company produces annually in excess of two billion kilowatt hours of electricity.

Because of the great size of these generator units—probably the largest ever built—unusual precautions are being taken to assure perfect ventilation and to keep heat generation at a minimum. The generators, of the open type so far as the air supply is concerned, will be surrounded by a housing which will form an air passageway completely encircling each generator unit. This air passage-way, as shown in the accompanying line drawing, takes the form of an eccentric setting, with the housing wall forming the outside of the eccentric itself. This form was decided upon in order to insure a constant air velocity. The fan attached to the rotor delivers the air into this passageway. Two large fan units direct connected to the top-like passageway forming the large end of the eccentric, and placed in parallel, draw the air exhausted from the generator by the rotor fan along the passageway, and outside through a duct opening in the wall. No air washers will be used with these units as the air in the building is considered of sufficient purity to eliminate any necessity for such installation. This is so because of the rather unique position of the station which is situated at the bottom of the gorge below the falls. It is in an isolated position and draws its air supply from an uncontaminated source.

Air for cooling the generators will be drawn from the generator room itself. Since, however, the heated air will be blown out of the power house, a constant circulation of fresh air will be maintained, the supply being allowed to enter the power house through the windows. The air will be admitted to the machines themselves through openings provided near the shafts, both at the top and bottom. These openings have been proportioned to admit the required amount of air, which is approximately 125,000 cu. ft. per min. These openings, it might be mentioned, are quite irregular. Air to the turbine pits will be admitted through several large openings as well. During the winter months it is proposed to recirculate a certain amount of the air. No special precautions or steps are being taken for noise elimination, although the housing surrounding each generator providing for the collection of hot air, will, it is presumed, make for comparatively noiseless operation.

Two fans will be used with each of the three generating units. These fans are No. 14 Buffalo conoidal, full housed, with special discharge connections, louvre dampers and flexible couplings. Approximate weight of each fan is 8000 lb. Three of the fans will be right handed and the other three left handed. Air capacity per minute for each fan will be 77,500 cu. ft. against 0.87 in. static pressure when driven at 289 r.p.m. Required brake horsepower will be 30.

Heating Problems Discussed

PAPERS ON USE OF CENTRAL STATION HEAT AND FLOW OF CONDENSATE MIXTURES ARE OF INTEREST

AT THE annual mid-winter convention of the American Society of Heating and Ventilating Engineers held at the Pennsylvania hotel, New York, Jan. 22 to 25, a number of papers were presented which should be extremely interesting to engineers who have heating problems to take care of either from the point of view of design or operation.

Among these was a paper: "The Economical Utilization of Heat from Central Station Plants," by N. W. Calvert and J. E. Seiter in which the authors pointed out the importance of installing sufficient and properly located radiation surface, shutting off for the maximum possible time at night, saving the heat in the condensate by the use of economizers, correct temperature control and reduction in transmission losses.

Operation of a steam heating system supplied from a central plant is fundamentally different in several respects from that of an isolated plant and system. In the case of an isolated plant, the variation in the amount of heat furnished to a building depends almost entirely on the rate of firing the boiler, whereas with central station heat, there being an unlimited supply, the amount of heat used depends entirely on the method of operation. While this unlimited supply lends a marked flexibility of operation, it also presents a great possibility of waste, inasmuch as with the isolated boiler a positive act, such as putting on fuel or opening drafts, is necessary to maintain the supply of heat thus increasing the cost of heating; whereas with central heat the positive act is required to cut off the heat supply, thereby reducing the heating cost. This difference may be exemplified by assuming a building being heated and no attention paid to it. If it is served from an isolated plant, the fire soon dies and the expense practically ceases but if it is using central heat, as long as the supply valve is left open the expense continues.

With an isolated plant the complete utilization of the heat content of the steam is not essential because the condensate returned to the boiler at a high temperature and less fuel is required to make it into steam again. With central heat, however, complete utilization is essential for economy, as the consumer must pay for every B.t.u. which is put into the steam and consequently suffers considerable loss if 10 to 15 per cent of the total heat content of the steam is sent to the sewer with the condensate.

Economy is effected by shutting off steam entirely, especially during the night when the majority of buildings are unoccupied. Inasmuch as the rate of heat transmission from a building is dependent on the differential tem-

perature between the interior and exterior it is evident that when the interior temperature is reduced heat will not be given up by the building as rapidly as if a high temperature is maintained. In buildings where steam is left on during the night, the interior temperature frequently increases and consequently the loss by transmission through the building walls increases. The average building cools very slowly and it is possible by a knowledge of the rate of cooling to utilize, during the period in which the building is occupied a large proportion of the heat put into the building. In an office building steam might be shut off an hour or two before closing time without making it uncomfortable for the occupants, inasmuch as in the coldest weather during tests the rate of temperature drop was only 5 deg. in 3 hr.

It should be noted here, however, that a building must have sufficient radiation to heat up readily in the morning, as instances have been found where building with insufficient radiation required steam on all night in order to have a suitable temperature during business hours, with consequently increased steam bills. Excessive radiation, on the other hand, also increases the consumption by overheating the building and necessitating the opening of windows.

A condition frequently met is that in which, on account of incorrect design of the heating system for central heat, it is necessary to heat the entire building or at any rate a large portion of it for 24 hr. a day, because heat is required in one small part of it.

The remedy for such cases is a separate main run from the service point to the part of the building requiring continuous service. The balance of the heating system may be shut off at all times when the building in general is unoccupied with a resultant economy in operation.

Separate lines and separate valves for operating different parts of a heating system independently according to their demand for heat simplify economical operation, but to make them most successful they must be conveniently located and easy to handle. The operating engineer, no matter how ambitious, will not run from one part of a building to another, closing valves here and there, just to save a little money for someone else. Therefore the insulation of valves should be such as to require a minimum amount of time and effort for operation.

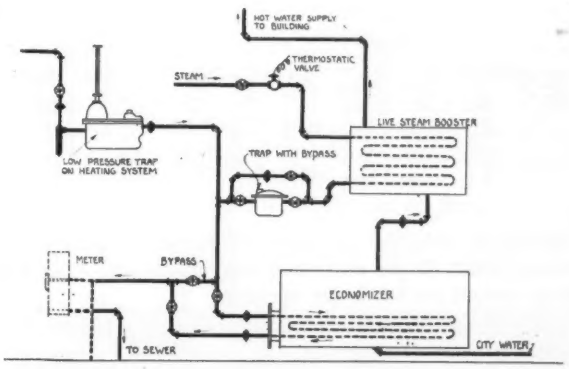
In a final analysis, proper temperature control at all times is the key to economical operation of a central heating system. The simplest form of control is that effected by manual operation of valves but there are numerous devices on the market for mechanical control of building temperature. For a small building the unit thermostat method, in which the steam supply for the entire building is controlled by a single thermostat, is satisfactory, especially with time attachment for lowering the temperature maintained during periods where the building is unoccupied.

The installation of a vacuum pump on a heating system using central service is a desirable feature from the standpoint of economy of operation. One of the greatest assets of a vacuum system is the positive removal of air which guarantees quick circulation. This insures even distribution of heat throughout the building and permits it to be brought up to the desired temperature in a minimum time after it has been allowed to cool down. The rapid heating of a building makes it possible to keep steam shut off for longer periods of time.

The heat of the liquid constitutes about 15 per cent of the total heat of the steam used for heating buildings and there is little of it given up by the condensation in most types of heating systems. In many central heating systems where the condensate is not returned to the boiler plant but is permitted to go to the sewer before the heat is extracted, a considerable waste occurs. To utilize a portion of this otherwise wasted heat the installation of some sort of economizer is desirable. These economizers are divided into several classes, according to their construction and use, as indirect air heating, direct air heating and water heating economizers.

The indirect air heating economizer consists of a coil enclosed in a sheet metal box in the basement, with a register in floor leading to the room above. The air inlet is arranged to take air from the basement or from outside. While this type of economizer is quite efficient, the cost of installation is rather high in proportion to the economy effected. The application of the direct air heating economizer is limited to heating systems having sufficient pressure in the return lines to raise the condenser to the economizer.

The majority of buildings use hot water in sufficient quantities to warrant the installation of a storage tank



METHOD OF INSTALLING WATER HEATING ECONOMIZERS

containing adequate heating surface so that by passing the condensate through this tank, the heat may be transferred to the water. Such an installation constitutes the water heating economizer.

In the selection of an economizer, obviously the variation in the heat available in the condensate, the water requirements, the amount of heating surface, the amount of storage capacity, the actual return on the investment, and the proper piping layout must be considered. The recommended method of installation of a water heating economizer is shown in the accompanying figure. A live steam booster is placed above the economizer so as to heat the water to the temperature required throughout the building. This temperature is regulated by a thermostatic valve on the steam main. Returns from this heater also pass through the economizer. Cold water enters the bottom of the economizer and is heated by the condensate and the tempered water leaves the top of the economizer and passes through the booster into the system. If recirculating lines are installed on the hot water system they should be connected to the bottom of the booster and not the economizer, otherwise the storage in the economizer will be filled with hot water heated by the booster and effectiveness of the economizer impaired. The valve of the heat salvaged increases very rapidly as the steam consumption increases until the limit of the economizer is reached.

After this limit is reached, it increases much more slowly in proportion to increases in heating requirements. There is some particular size of economizer which will show the highest return upon the investment.

A water heating economizer is a paying investment on any size heating system if there is sufficient hot water demand to utilize some of the available heat in the condensate, and if the temperature of the returns is not too low due to the use of atmospheric or vapor systems; however, care must be taken to provide ample heating surface and storage capacity in order to have an efficient system.

Flow of Steam and Condensate Mixtures

In the paper by Houghton, Ebin and Lincoln, "Critical Velocity of Steam and Condensate Mixtures in Horizontal, Vertical and Inclined Pipes," some interesting deductions were set forth. Previous experiments on the flow in vertical pipes established that the critical velocity varies from 20 to 30 ft. per sec., that it is determined by the smallest area of the pipe; that squared entrances reduce the critical

TABLE 1. CAPACITIES OF VERTICAL AND HORIZONTAL ONE-PIPE LINES

Allowable Velocity in Feet per Second

Nominal diam. of pipe in in.	18 Cond. in lb. per hr.	18 B.t.u. loss per hr.	18 Sq. ft. rad. based on 240 B.t.u.	18 Pitch of pipe in./10 ft.	22 Cond lb. per hr.	22 B.t.u. loss per hr.	22 Sq. ft. rad. based on 240 B.t.u.	22 Pitch of pipe in. per 10 ft.
¾	8.9	8,640	36.0	1.00	10.9	10,580	44.1	2.6 to 3.0
1	14.5	14,070	58.6	0.75	17.8	17,270	72.0	1.7 to 2.0
1¼	25.2	24,460	101.9	0.50	30.8	29,890	124.5	1.00
1½	34.2	33,190	138.1	0.50	41.8	40,560	169.0	1.00
2	56.5	54,830	228.4	0.50	69.0	66,960	279.0	1.00

velocity by about 10 per cent and burrs left by a wheel cutter, about 30 per cent; and that unions and other fittings should have full size openings.

The present series of experiments brought out the following points:

For vertical pipes the curve of velocity against steam header pressure rises rapidly until a point is reached, where drops of condensate are caught up by the steam and shot back in the direction of steam flow, at which there is a marked flattening out.

When rings of water appear at the entrance of the tube, the point is reached where no further increase in pressure will increase the rate of flow. Further pressure increase causes intermittent flow, i. e., slugs of condensate are carried back up the pipe. This point is affected by the length of the pipe; the longer the pipe, the greater is the pressure required. The design of the entrance of the tube also has a marked effect on the maximum velocity attainable.

In horizontal runs, so called, having a pitch under 2 deg. the condensate, at low pressure, travels in a smooth stream along the bottom of the pipe. As the pressure is increased waves appear on the surface of the condensate which travel toward the radiator. For small pitches a given steam velocity produces greater waves, consequently there is greater resistance to the flow of steam and the quantity is reduced.

For small pitches from 0 to 2 deg. the maximum velocity increases rapidly with the pitch. During this period the maximum velocity varies considerably with the length of pipe.

As the pitch is increased beyond 2 deg., the maximum velocity continues to increase, almost directly proportional to the angle of pitch until the maximum is reached at an angle of 35 to 50 deg. depending on the size of pipe.

From 50 to 90 deg., the effect of the entrance of the pipe continues to increase and the maximum velocity decreases, until at a pitch of 90 deg., i. e., on a vertical pipe, the entrance to the pipe is the main factor affecting the maximum velocity.

Velocity of flow becomes zero when the nominal pitch as expressed in inches for the actual length of pipe becomes a negative value somewhat smaller than the internal diameter of the pipe, or in other words when the absolute pitch is nearly zero.

In general, the maximum velocity increases with the pipe size up to about 1¼-in. diameter. Beyond this size, the maximum velocity is practically independent of the pipe size, a relation which seems to hold good regardless of the pitch of the pipe.

As a result of these tests, tables have been compiled showing the capacities of various sizes of pipe when used under different conditions. In former tests, a velocity of 22 ft. per sec. was established as being the minimum critical value and 18 ft. per sec. was taken as allowing a factor

TABLE 2. CAPACITIES OF ONE-PIPE LINES AT VARIOUS PITCHES

Nominal diam. of pipe in in.	¼ Cond., lb./hr.	¼ B.t.u. loss/hr.	¼ Sq. ft. rad. based on 240 B.t.u.	½ Cond., lb./hr.	½ B.t.u. loss/hr.	½ Sq. ft. rad. based on 240 B.t.u.
¾	6.19	6,010	25.0	7.48	7,260	30.3
1	11.32	10,990	45.8	13.02	12,630	52.6
1¼	25.95	25,180	104.9	29.00	28,140	117.2
1½	35.25	34,210	142.6	39.30	38,140	159.0
2	58.40	56,670	236.0	65.20	63,270	263.5
	1			1¼		
¾	9.22	8,950	37.3	10.00	9,700	40.4
1	15.58	15,110	63.0	17.30	16,790	70.0
1¼	32.93	31,950	133.0	35.75	34,690	144.5
1½	44.80	43,470	181.0	48.60	47,160	196.5
2	74.10	71,910	299.5	80.50	78,120	325.5
	2			3		
¾	10.50	10,190	42.5	11.40	11,060	46.1
1	18.60	18,050	75.2	20.55	19,940	83.0
1¼	38.10	36,970	154.0	40.80	39,500	165.0
1½	51.80	50,270	209.3	55.50	53,860	224.0
2	85.70	83,160	346.5	91.90	89,180	371.5
	4			5		
¾	11.74	11,390	47.5	12.19	11,830	49.3
1	21.75	21,110	87.9	22.31	21,650	90.2
1¼	42.68	41,420	172.6	44.07	42,760	178.2
1½	58.10	56,350	34.8	60.00	58,220	242.6
2	96.80	93,240	2388 4	99.21	96,270	401.1

of safety of 20 per cent. Table I gives the capacities on this basis for various sizes of pipe at different pitches and shows that smaller sizes require greater pitches to maintain in the required velocity. A pitch commonly used of 1½ in. per 10 ft. run will give a velocity of 20 ft. per sec. for ¾-in. pipe and 26 ft. for 2-in. pipe, corresponding fairly well to the capacities in the right hand side of the table for a velocity of 22 ft.

Table II gives, for horizontal runs, the increase in capacity as the pitch increases. The tests show that for pipe above 1¼-in. the velocity is independent of the size of the pipe. It will be seen that a 1½-in. pipe with a pitch of 1 in. in 10 ft. will supply 181 sq. ft. of radiation, while a 1¼-in. pipe with pitch of 5 in. in 10 ft. will supply 178 sq. ft. Increasing the pitch of the pipe reduces the size required and, where such increase is possible, may result in a considerable saving in cost.

Power Increased From an Overloaded Engine

By Changing the Size of Flywheel and Installing Piston Valves the Engine Was Speeded up to Gain 25 Per Cent More Power

AS AN industrial plant grows, the question of additional power often becomes critical. Consideration must be given to the disposal or use of the additional exhaust steam, the question of initial cost and an item of vital importance in many plants is that of floor space available for an additional unit or a unit of greater capacity. It often occurs that the engine room is completely surrounded by buildings in which production is carried on. This means that space is at a premium and that additional power must be derived with the greatest conservation of floor space or a new plant must be constructed. At the outset, this latter proposition will require a large initial expense for it practically means the abandonment of the old plant.

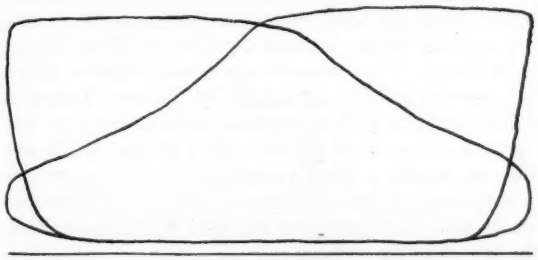


FIG. 1. INDICATOR DIAGRAM SHOWING THE LOAD ON THE ORIGINAL ENGINE

In Kalamazoo, Mich., the Western Board & Paper Co. was confronted with just such a problem as is outlined above. Additional boiler capacity was readily obtained by the installation of an additional stoker fired vertical water-tube boiler. The real problem to be met was that of additional power required due to the enlarging of a paper machine department. Up to the time of the changes in this production department, it had been furnished with power by means of a rope drive from a Corliss engine which was built by the Strait Manufacturing Co.

This engine had been installed about 14 yr. ago, at which time it was well able to carry the load. The gear was of the releasing type, the single cylinder was 24 by 48 in., the speed was 81 r.p.m. and the 18-ft. flywheel was provided with rope grooves. High pressure steam was delivered to the engine at 148 lb. ga. with but a 2 lb. drop between the boilers and the engine. The exhaust pressure was maintained at about 7 lb.

All exhaust steam from this engine was required in the mill. The increase in the mill capacity required additional low pressure steam, therefore, there was no economy to be expected by replacing the old unit with one which required less steam per indicated horsepower. A survey of the new requirements indicated that about 25 per cent additional horsepower was required and this could not be obtained, even in part, by an increase in steam pressure without refitting the pipe line layout and the use of reducing valves on lines to certain old units which could not safely be adapted to a higher pressure.

Floor space was at a premium, since the old unit was located across the width of the engine room with the flywheel or shieve-wheel close to one wall and the cylinder head just far enough from the opposite wall to allow a fair passageway. The extent to which the old unit was loaded is shown by Fig. 1, in which the cutoff is shown at more than one-half of the stroke, at which time the engine was developing 750 hp.

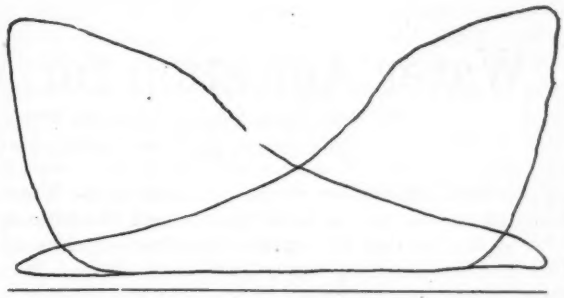


FIG. 2. FULL LOAD DIAGRAM TAKEN AFTER THE NEW CYLINDER WAS IN PLACE

Examination of the engine foundation proved it to be in excellent condition. The engine frame and trunk were amply strong for an engine developing 950 to 1000 hp. In fact, everything pointed to a rebuilding of the old unit as the solution which would be the most economical and which would satisfactorily serve the new load conditions.

Problem Solved By Increasing Speed

This problem was put up to the Fitchburg Steam Engine Co. who recommended speeding up the engine to obtain the additional 25 per cent increase in power. To make this change required first that the 18-ft. flywheel be replaced with one 15 ft. in diameter since it was found that the rim speed and stresses due to the higher speed would make the old wheel dangerous. The cylinder size was to remain the same, that is, 24 by 48 in., the speed increase then was from 81 to 107 r.p.m. It was decided that the old valve gear was not well adapted to the higher speed and further it would not do for use with superheated steam which was to be supplied with the installation of radiant type of superheaters which were being installed in the boiler settings.

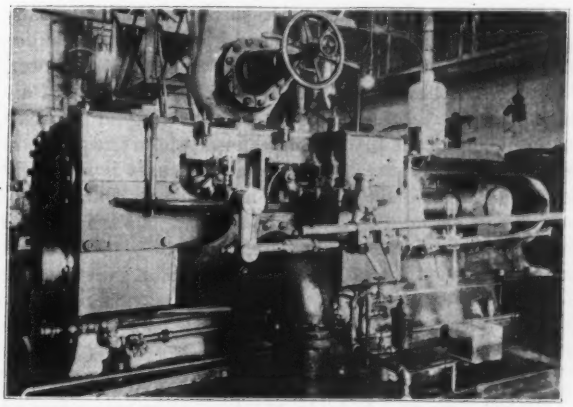


FIG. 3. VIEW OF THE NEW CYLINDER AND PISTON VALVE GEAR

These conditions were met by the installation of a new cylinder which is provided with cylinder valves. Two eccentric rods are run from the eccentrics to rocker arms located opposite the crank end of the engine trunk. The upper or hook rod extends from one rocker arm to operate two separate cylinder valves, one of which admits steam at each end of the cylinder. The exhaust side rod extends from the short rocker arm to the exhaust cylinder type valves which serve both ends of the cylinder. All valves are fitted with an adjustment whereby wear may be taken up and leakage past the valve stopped.

When finally hooked up and put into service this rebuilt engine produced the cards as shown in Fig. 2 when developing 950 hp. at 107 r.p.m. This engine now meets all the requirements of the departments which it serves and the change for additional power was made at a low cost and with the use of no more floor space than was required by the original unit.

Water Agitation for Making Raw Water Ice*

Oil and Carbon May Be Eliminated From the Blowing Air by the Use of Blowers Instead of Compressors. By Van R. H. Greene

ALL WATER contains air and it is due to the formation of this air in small particles on the forming sides of the ice that the crystal structure is broken up. This produces anything but a clear block of ice. It is therefore necessary that some form of continuous action in the freezing process be employed to prevent the formation of these air particles. This can be accomplished either by agitating the water in the can or by frequent shaking of the can so that the air is removed from the sides of the ice. The agitation of the water by means of blowing air has given the most satisfactory results up to the present time.

Low pressure air was the first employed. It consisted of drop tubes hung in the center of the ice can and extending to within 6 in. from the bottom of the can. The air, which is equal in pressure to the submergence of the tube in the can, was forced by means of a blower through laterals which extended along the side of the tank and then through cross pieces, from which the air was distributed through drop pipes into every individual can.

This system has been most successful and its many advantages have been acknowledged by all who are familiar with its use. In the first place, it is economical in power, requiring the blowing of a relatively small amount of air against low pressure. This effects a saving of approximately 10 per cent in the total kilowatt-hours required to produce a ton of ice. In the second place, it is relatively fool-proof, due to the fact that air is blown continuously into the center of the ice can. The tube always remains in the unfrozen water and therefore more than 34 or 35 hr. of freezing time is not subject to being frozen in the ice. At the expiration of this time it is always necessary to remove the tube, suck out the unfrozen water and refill with fresh water.

Salts Concentrate in Core Water

It has been contended by many that the concentration of the salts in the core water are such that the freezing time is delayed even more than that which is due to the loss incident to refilling the sucked out core with fresh water. With this statement, however, the writer cannot agree, since aside from such waters which are found in Texas, Florida and other sections of this country the mineral content of the water is not sufficiently great to cause any loss in freezing time due to this salt concentration. The ideal system to be developed in the future would be one which does away with the necessity for removal of the core, which requires no labor other than the regular can pullers and which, if possible, will be as economical in power cost as the low pressure system.

In the ideal high-pressure system air would be conducted through a tube which would be soldered either in the side or in the corner of the ice can, or suspended in the can from a bracket supporting the tube from the side of the can. The pressure when the can was first filled with water would equal that of the low pressure system. As the ice formed on the side of the can to a point where it covered the tube outlet the pressure in the tube must necessarily rise to a point where it could continue to blow through pores in the ice. This pressure would vary between 12 and 15 lb., depending upon the density of the ice. This pressure then limits us to the low point, beyond which we cannot go and obtain a satisfactory block of ice. If it were possible to operate a plant successfully on 15 lb. pressure the horsepower required to compress the air would compare favorably with the horsepower required to compress the air in the low pressure system.

In all systems employing high pressure air the use of air driers is required, otherwise the moisture which is always present in air will freeze out in its passage down this tube, form ice and ultimately stop the tube from blowing.

Drying of air is regulated by varying the temperature of the air or the pressure of the air, or both. The present method of drying air is to hold it to a temperature of around 30 deg. F. under a pressure of 25 lb., so that when it is expanded to 2 or 3 lb. pressure it has a dew point of 10 to 12 deg. F. This dew point being below the temperature of the brine surrounding the cans means that the air is sufficiently dry so that no moisture is precipitated until a temperature below 10 to 12 deg. F. is reached and as this pressure is below the brine temperature no trouble from freeze-ups due to moisture should be expected. If this air were still further reduced from 30 deg. F. to 20 deg. F., and the same percentage of dryness be required, i. e., a dew point of 10 deg. to 12 deg. F., it would not be necessary to compress this air to a pressure in excess of 15.

Along these lines, a number of plants have been installed during the past year wherein air driers of a more modern and more efficient type have been employed and where the air has been successfully cooled to a constant outlet temperature of 20 deg. F. at a pressure as low as 12 lb. Along with the development of the new type of air driers and the possible operation at 12 to 15 lb. or less another great improvement has come about in the way of using a special type of high pressure blower which can be made to operate at 20 lb. pressure. This does away entirely with the use of air compressors which have always been troublesome from the standpoint of fouling the air with the oil and carbon.

* Abstract of paper read before the Memphis Convention of the N. A. P. E.

Two Types of Driers Are in Use

There are two distinct types of air driers used in conjunction with the usual high pressure system. One is the shell type of cooler installed in a battery of two and so arranged that the air passes through these two coolers in series. Cold brine from the freezing tank is pumped through the coolers, counter current to the flow of air. In this form of drier the air is reduced to the dew point in the first drier and the moisture is frozen out in the second. This means that the second drier becomes ice bound and must be defrosted, which is accomplished by means of a three-way valve which permits of an interchange of these two series driers. The other type of drier consists of cylindrical tanks arranged with air distributors located at the bottom, through which the air is blown. One tank is approximately half full of water and the other half full of brine. The advantage of the second type of drier over the first is that no manual manipulation is necessary, except at long intervals to see that the salt brine in the second stage drier has not weakened to a point where it will freeze at the low temperature required for the air. The disadvantage of the second type of drier is that unless properly designed and carried at the proper temperature,

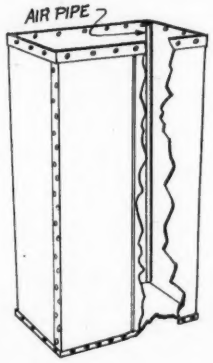


FIG. 1. ICE CAN WITH AIR TUBE BUILT IN AS AN INTEGRAL PART OF THE CAN

salt will be carried over with the air. This will have a tendency to crystallize out in the laterals and stop up the reducing fittings. If this air is to be free from salt it must be reduced to a temperature which is even lower than that required for the total elimination of moisture.

In the first drier, best results from the standpoint of economy are obtained by cooling the air to 20 deg. F. under a pressure of 20 lb. and taking care of the proper manipulation of the valves so as to be sure both driers are functioning properly and not frozen up. In the second type it is absolutely necessary to operate under a temperature of 20 deg. F. in order to insure protection from salt being carried over and interfering with the operation of the plant.

White Ice Due to Pressure Failure

In most raw water plants a large percentage of white ice is noticeable which is not necessarily due to the working of the drier but to the fact that the pressure on the tube beyond the reducing fitting in the lateral is rising and falling, depending upon the growth of ice in the cans. This rising pressure exerts its influence on the tightness of the fittings and hose which enters the tube in the can. If the tube and fitting are not tight then instead of the pressure increasing at the outlet of the tube to overcome the resistance of the forming ice, air will leak out from the hose or the fitting equal in proportion to the rising pressure. When once stopped, no amount of pressure will open up the pores in the ice sufficiently to permit of the flow of air again. This, of course, must of necessity result in a white block.

One of the great advantages of a system wherein the cans are not removed from the tank is the possible reduction of can pulling and other unskilled labor. In order to meet this problem with the high pressure type of plant there has been developed in the last year or so a number of systems of multiple can harvesting. In all of these systems, baskets of various kinds are used to hold from four to twenty-four cans per basket and special cranes are then used to permit the removal at one time of anywhere from 4 to 24 cans.

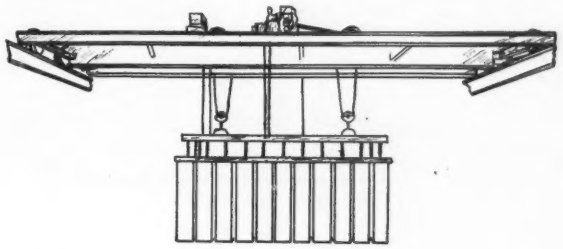


FIG. 2. OVERHEAD CRANE REMOVING ELEVEN CANS AT ONE OPERATION

These systems are, of course, more expensive than the old time method of harvesting systems but are economical from the standpoint of saving in unskilled labor particularly in plants of 100 T. capacity or over. The work of the can puller with these systems has become one of machine operation rather than of brute strength, a movement which always tends to improve the operating conditions of the plant. It also makes possible the use of other members of the operating force in case of absence of the regular can pullers. The number of white cakes is also reduced due to the simplicity of the air piping of such systems.

Explosibity of Dust

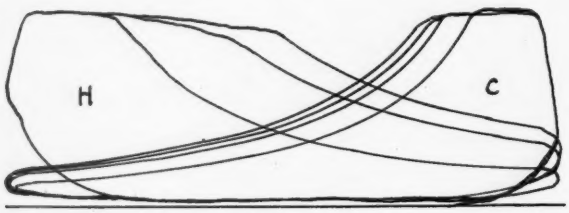
If you are bothered with dust of any kind it is advisable to be careful. Dust is explosive, particularly if the dust is made up of combustible particles. Disastrous dust explosions have occurred in many of the industries and we know enough about dust and its explosibility now so that we should at least be cautious.

It is not necessary to "wonder" whether or not a given dust is explosive and just how dangerous it is. Simply send a sample of it to the Bureau of Chemistry, Department of Agriculture, and they will test it. After the test they will inform you whether or not it is explosive and also what should be done to avoid danger.

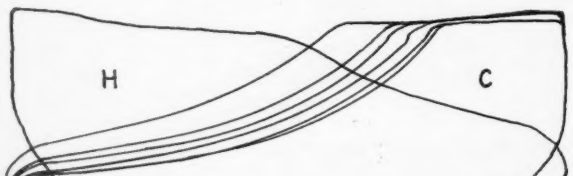
It is far less expensive to send a sample to the department of Agriculture than it is to take a chance with the possibility of an explosion which may result not only in the loss of property but in the loss of lives.

Valve Adjustment Cured a Sluggish Governor

RECENTLY, THE writer indicated a 30 by 48-in. Corliss engine in rolling mill service where the load varied quickly from no-load to heavy overload. Frequently the governor would be nearly down to the stop and sometimes would ride



NO. 1



NO. 2

FIG. 1. DIAGRAM WITH SLUGGISH GOVERNOR ACTION
FIG. 2. IMPROVED DIAGRAM AFTER VALVE ADJUSTMENTS

the stop. The engine acted sluggish and diagram No. 1 shows the cause.

Steam admission was late on both ends and, at heavy load, the pressure was high at the end of the stroke so that the steam was slow in exhausting.

Steam and exhaust eccentrics were moved ahead, also the exhaust radius rod shortened so as to give earlier admission, earlier release and wider exhaust port opening with reduced compression. Governor rods were adjusted with the governor blocked in mid-travel position.

After all adjustments were made diagram No. 2 was taken, letting the pencil travel several strokes to catch the fluctuating load. TOM JONES.

Burlington, Ia.

Pitting and Corrosion of Heating Boilers

EVERY BOILER inspector knows that the average steel heating boiler is subject to pitting and corrosion, both internally and externally, the nature and extent depending on operating conditions, care, type of boiler, type of setting, proportion of condensation returning to boiler, and other such items.

Usually the average power boiler is not as subject to pitting and corrosion, except in certain particular parts, such as the edges of leaky handholes and manholes.

Considering internal conditions, we find that when a boiler is coated with scale, there are no active corrosive conditions on the coated surfaces. The average heating boiler is not coated with scale but the bare unprotected metal surfaces are exposed and are usually corroded. Well designed heating systems usually return all condensation, except losses through air valves and leaks to the boilers. Condensation is distilled water and therefore does not ordinarily contain any impurities or scale forming substance. The amount of city or raw water used to make up for incidental losses is negligible and the amount of scale forming substance introduced by this means is, therefore, negligible. As a rule then, we do not find scale in heating boilers but we do find pitting and corrosion, which often destroys the tubes in a surprisingly short time and also affects the stays and shell.

Surfaces coated with scale do not corrode. Unprotected surfaces do corrode. The remedy for corrosion, then resolves itself into the problem of knowing how to coat the surfaces with a thin scale or its equivalent. Oil and excessive scale, must however, be avoided. Raw water used in sufficient quantities, will coat a boiler with scale but for the sake of economy, we do not want to use raw water if we can use hot condensation.

Analysis shows that raw water usually contains forms of lime and magnesia. It would seem, therefore, that if we introduced lime or other similar substances into the water in our heating boilers, we in time would create a coat of scale. At this juncture, I wish some of our chemical friends would step into the discussion. Any agent suggested should no doubt, be added regularly and in small rather than large quantities. If an over-saturated solution were created in the boilers, only rapid circulation would keep the agent in suspension.

Properly painted a piece of metal does not rust where the paint adheres, however, there are many boiler surfaces that cannot well be painted, due to temperature conditions. It is not, however, during the high temperature periods, that the bulk of external corrosion occurs; it is rather during the summer months when the boilers are idle, when the cold surfaces sweat and rusting occurs.

Heating boiler surfaces are frequently not properly cleaned. Ash is found in fireboxes and soot on the heating surfaces. As moist soot and ash are actively corrosive, the result is the boiler inspector reports general and sometimes local corrosion and pitting. Eventually, the boiler owner or user is presented with a bill for repairs or even for a new boiler. It is evident that to save the surface and, therefore, to save all, we should try to keep the boiler surfaces dry and clean. The surfaces where accessible, may be wire brushed. I know of one plant where the heating boilers are wire brushed and then coated with

heavy oil. These boilers are in excellent condition. The oil prevents the water from coming in contact with the boiler surfaces and arrests corrosion. Water, it should be noted, will not of itself corrode metal but assists oxygen to form a chemical union with iron or steel, thus creating iron oxide (rust). The heating surfaces of the tubes (fire-tubes) can easily be coated by means of a suitable swab soaked in oil.

Handhole and manhole covers and other joints and seams should be kept free from leaks. Such leakage, too often, is the cause of corrosion that necessitates expensive repairs.

"Should I drain my boiler in summer or should I leave it full of water?" Practically every heating boiler attendant asks every inspector this question. Judging from experience, I am of the opinion that this question cannot be answered off-hand. Each case must be considered on its own merits.

Many attendants drain their boilers and open up all manholes and handholes to permit a free circulation of air throughout the boiler, with the object in view of drying the surfaces and keeping them dry. This works well in practice, provided the boiler room is warm and dry and the design of the boiler such that the circulation of air is not restricted. It would seem, then, that if we have cool damp basement conditions and a boiler in which air circulation through the water spaces is restricted, that we had better choose between the lesser of the evils and fill the boiler completely with water. This will afford reasonable protection to the internal surfaces of the boiler. Cast-iron boilers are in one of the general classes of boilers that should be kept completely filled with water. Cast iron does not rust easily. Filling cast iron boilers with water naturally reduces the summer-time cracking hazard, when paper and rubbish is burned without thought as to whether or not there is water in the boiler.

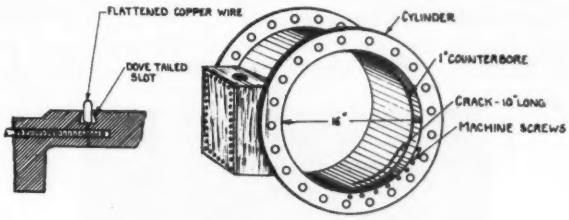
When boilers are completely filled with water, it would seem to be good practice to heat the water to at least the boiling point to assist it in getting rid of the free air or oxygen that may be held in solution. In protecting the internal surfaces, we must not overlook the external surfaces. There may be times when a boiler will sweat more readily, when it is filled with water.

What we must be careful about is slight leaks at the tube ends, manhole and handhole joints, the boiler seams, etc. These leaks can cause much corrosion during the summer months and may occur at parts of the boiler that are not readily accessible. W. H. E.

Repairing a Steam Engine Cylinder

In starting up an old slow-speed slide-valve engine in a marble yard in New York, the cylinder was found to be leaking at the bottom of the head end. On removing the head the cylinder was found to be cracked inside of the counter-bore for a distance of about 10 in. around the bottom circumference of the cylinder. When the repair man was called in he said that the cylinder had been frozen as the plant had been idle all winter but the owner insisted that that was not the case; however, there no time to get a new cylinder as there were several hurry-up jobs on hand and a temporary repair was undertaken.

Six holes were drilled and tapped lengthwise through the cylinder wall for $\frac{7}{16}$-in. machine screws extending 1 in. beyond the crack. The screws put in and the heads cut off flush with the face of the flange. A dovetailed slot was then cut the length of the slot as shown in the accompanying sketch. A piece of copper was annealed, and flattened to the thickness of the top of the slot driven in, and peened. The top was then smoothed off to the bore of the cylinder. This was to have been only a temporary job to last until some time was available for a permanent repair



CRACK IS HELD TOGETHER WITH STUDS

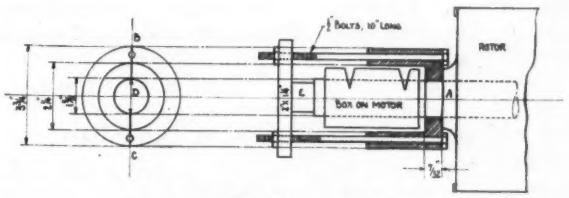
but the engine has run continuously for over 2 yr. since the repair was made and is still in service.

Utica, N. Y. M. M. Brown.

Bearing Repair

We had the misfortune, a short time ago, of having a motor bearing heat up and seize so that we could not turn the shaft. This motor was being used on a job where it could not be out of service for any length of time without interfering with the operation of the whole shop. We did not have a spare box for this unit, hence it was up to us to get the box off the journal without jamming it so that it could not be used again.

We first took out the bearing casting with the rotor and shaft, then we took out the set screw that held the



BOX PULLER IN PLACE

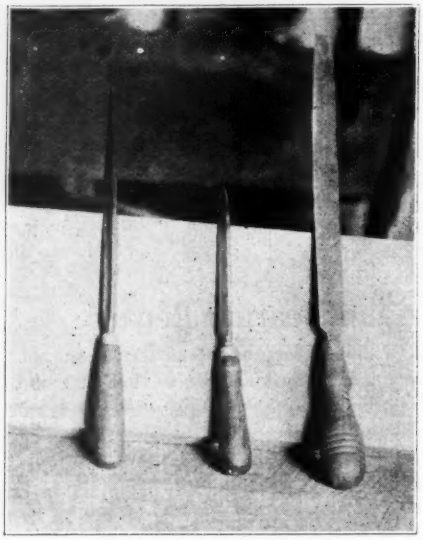
box in place, also the small pin that keeps one oil ring from jumping over into the other ring groove. After that we took off the bearing casting leaving the box on the shaft.

As shown in the accompanying sketch, we had only $\frac{7}{32}$ in. between the box and the rotor, which did not leave us much space in which to work. We had at hand a steel disk, $3\frac{3}{4}$ in. diameter by 3 in. thick which we put in a lathe and bored a hole through the same size as the shaft diameter ($1\frac{5}{8}$ in). Then we bored another hole, large enough to go over the box, to within $\frac{7}{32}$ in. of the face. We then drilled two $\frac{9}{16}$-in. holes at "B" and "C" then cut the disk at "D," along a diameter through the center of these two holes. These two halves were then put over the box, with two $\frac{1}{2}$-in. bolts in place, and clamped together. By putting a steel bar across the end of the shaft at "E," the box was pulled off by tightening up on the nuts on the $\frac{1}{2}$-in. bolts. After cleaning up both the box and the shaft, we easily reassembled the bearing and put the motor in operation. A. A. Williams.

Gardner, Mass.

Old Files Make Good Bearing Scrapers

THE THREE bearing scrapers shown in the accompanying illustration were easily made from files that had outworn their usefulness. Two of these files were three cornered and the third was half-round. The scraper at the left is hollow ground. The teeth were first ground off on an emery wheel and then the sides were cut concave with a saw gunner running at high speed. The scraping edges were then finished on a bench stone. The tool shown in the middle is a three-cornered flat-sided scraper that was



SCRAPERS MADE OF OLD FILES

made up in the same manner except that the saw gunner was not used. The scraper shown on the right was sharpened to a keen knife edge. These tools serve their purpose admirably and are comparatively inexpensive.

Walton, Nebr. DALE R. VAN HORN.

Making the Best of a Bad Job

SOME TIME ago I had occasion to inspect a horizontal tubular boiler that had a new "one-third sheet" installed front course of the shell directly over the fire box.

Both longitudinal seams were below the fire line, and consequently exposed to the action of the products of combustion and radiant heat from the furnace and furnace walls. The seams were of triple riveted double butt strap construction. A coating of white lead had been applied to the inner faces of the butt straps before they were put in position. The design of the seams was fitting and proper, because they corresponded with the design of the other longitudinal seams in shell. There is no particular criticism on the coating of the butt straps with white lead. There was serious objection, however, to the location of the seams. A joint of such heavy construction plus the layers of white lead could easily become overheated if the boiler were forced. The location of seams was an ideal one to aid in the accumulation of loose scale that often circulates in a boiler with the water currents, until it finds a resting place. Such an accumulation of scale in itself would be conducive to overheating of the shell or joint.

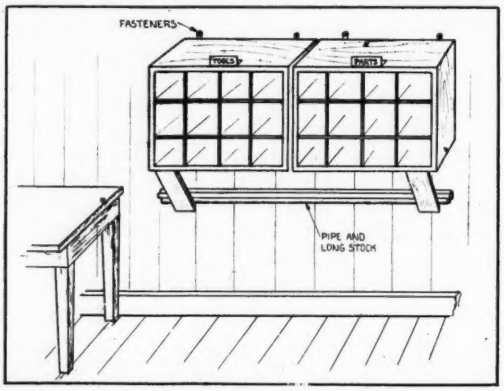
There was little room for contention, because according to the state law, the longitudinal seams of a boiler should be above the fire line. The first apparent remedy was to remove again all the boiler tubes, (which meant again retipping them and re-installing them) and removing the one third sheet for the purpose of installing a new half sheet. This would have meant the duplication of a job that had cost about $600. The problem would have thus been solved by raising the longitudinal seams above the fire line; however, a cheaper solution presented itself. The brickwork that had been removed from the fire walls had not been replaced, so it was suggested that the fire line be lowered by "raking in" the brickwork to cover the new joints.

This brought the fire line below the seams, thus protecting them as specified by law. W. H. F.

Partitioned Boxes for Parts in the Shop

INCONVENIENCE and lost time in searching around for parts and tools in the repair shop can and should be avoided by the proper disposal of these parts in containers or places where they can be located without necessitating this delay.

Simple containers suitable for storage purposes can be obtained without undue labor or expenditures for



TWO CRATES SECURED TO THE SHOP WALL, PROVIDE AN ORDERLY ARRANGEMENT FOR CARING FOR PARTS AND TOOLS

facilities. As a suggestion, two or more crates which have handy partitions in them are made into parts boxes by simply adding fasteners and securing them to the shop wall.

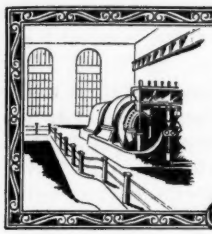
With these containers it is a simple matter to segregate the parts and tools and when any desired part is required, if the exact location is not remembered, the open rack facilitates locating of the material.

With an orderly method of taking care of materials, the repairs are more likely to be attended to and machinery kept in good operating order.

Washington, D. C. G. A. LUERS.

Notes on Piston Rings

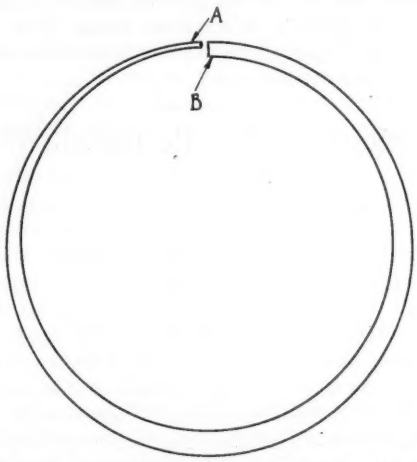
EDGES OF piston packing rings should never be left sharp; round them with a smooth file. They will then spread the oil in the cylinder, insuring better lubrication. Sharp edges are likely to scrape the oil off the surface. The edges will wear sharp in course of time. Whenever I remove a piston, I always use a file on the sharp edges of the rings. The ring should be perfectly free to move in its groove but should not have play sideways. If it is too loose, it may rattle and if too tight, unequal expansion of piston and ring may cause it to bind, when hot, and scratch or score the cylinder bore. TOM JONES.



QUESTIONS AND ANSWERS

What Caused the Uneven Wear?

WE ONCE had occasion to replace the eccentric snap rings on our 18 by 36-in. Corliss. They had worn to such an extent that the steam leakage past the piston became a serious item. On inspection, we found that that part of



ONE SIDE OF THE JOINT WAS WORN MORE THAN THE OTHER

the ring designated as A in the accompanying sketch had worn more than the opposite side of the joint B by more than $\frac{1}{16}$ in. This is a rather peculiar and unusual condition. What could have caused it? TOM JONES.

Charging Ammonia System

IN ANSWER to the refrigeration questions by J. B. in the February 1, issue on page 203, I submit the following:

1. To charge the system, connect the drum to the charging connection, having drum higher on bottom end. Close the main liquor valve on the receiver and open the charging and drum valves slowly, leaving the other expansion valves in the normal position. When frost shows on the bottom of the drum head, close the drum and charging valves and then open the liquor valve. The pressure will become normal again in a short time. It is preferable to slow down the compressor while charging to avert excessive pressure and also vacuum on suction while changing valves.

2. Need of ammonia is indicated when the liquor in receiver is low under normal operating conditions or when hot gas blows through to the expansion valve, so that there is no frost near the expansion valve. On wet systems it is indicated by frost leaving the suction line at the compressor, but on dry systems such is not the case.

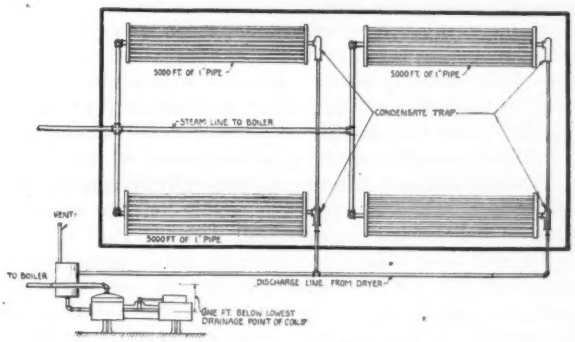
3. To empty the receiver, open the expansion and close the suction valve to one coil, trapping liquor in the coil. Close valve or valves between receiver and condenser and trap the rest of the liquid in the condenser. Open another expansion valve to drain the receiver until the gage shows a vacuum, then close the liquid valve on the receiver, running the compressor at slow speed to condense all gas in the condensor. Shut down an hour and then pump out the receiver again by opening the liquid valve.

St. Louis, Mo. E. G. M.

Condensate Return Lines

I WOULD highly appreciate the opinion of the readers of Power Plant Engineering as to the practicability of the dryer heating system arrangement shown in the accompanying sketch.

Each coil has a fall of 6 in. and empties into a return header. Two of these headers serving two coils each discharge into a common main which supplies the vented


5000 FT. OF 1" PIPE
5000 FT. OF 1" PIPE
STEAM LINE TO BOILER
CONDENSATE TRAP
VENT
5000 FT. OF 1" PIPE
TO BOILER
DISCHARGE LINE FROM DRYER
ONE FT. BELOW LOWEST DRAINAGE POINT OF COILS

PROPOSED ARRANGEMENT OF HEATING SYSTEM

receiver of the boiler feed pump, 1 ft. below the lowest drainage point of the coils. Return traps are used between each coil and the condensate return line. The pressure in the coils will not exceed 30 lb. G. S.

Engineer's Examination Questions

WHY IS it that the inside strap of a butt riveted longitudinal joint is usually wider than the outside strap?

2. Why is steam expanded to a pressure 58 per cent of the initial pressure in a steam turbine nozzle?

3. If a reducing valve is inserted in a steam line leading to an engine on a system where superheated steam is employed what effect will it have on condensation in the cylinder?

4. Is it possible to superheat steam while it is in contact with water? B. S.

ANSWERS

To preserve, to as great an extent as possible, the tensile strength of the shell plates of a boiler drum, the outer row of rivets on a butt joint are spaced farther apart than the others. With this construction the pitch between the outer row of rivets is too great to obtain a good calking edge unless the strap is made especially heavy or is scalloped to conform to the diagonal pitch. Such construction

is unnecessarily expensive as compared with the slight increase in the efficiency of the joint and for this reason the outside strap is made only wide enough to provide a lap for the inner row or rows of rivets, where the pitch is short enough to afford a good calking edge. The wider strap necessary for receiving the outer row of rivets is placed on the inside of the shell where calking is unnecessary.

2. In the design of steam turbines, the pressure drop across any set of nozzles is determined by the steam velocity which it is desired to obtain on the low pressure side. This velocity, for most efficient operation, bears a certain definite relation to the pheripheral speed of the movable blades. This value is, of course, fixed by the average radius at which the blade acts and the rotative speed of the shaft. This last factor is largely determined by external conditions, taking into account, of course, the limits of construction possibilities in the turbine itself. When the desirable steam jet velocity has been thus determined, the pressure drop required may be found and the nozzle may be designed to meet these conditions. The steam velocity may have almost any value depending on the design of the nozzle. With a simple converging nozzle or sharp edged orifice, there is a definite limit to the velocity attainable. This is what is known as the critical or acoustic velocity, which is equal to the velocity of sound in the medium and which occurs when the pressure on the low side and at the throat of the orifice has a value of approximately 58 per cent of the initial pressure. For any pressure on the low side less than this value, there is no further gain in jet velocity; instead the additional pressure difference between the critical pressure obtaining at the throat of the orifice and the existing back pressure dissipates itself in spreading the jet in a cone shape. In this condition, obviously, the steam is of little value in a turbine.

By adding a diverging nozzle to the original round edge orifice, to form a venturi nozzle, the steam may be made to expand to a value below the critical pressure and an increase in velocity will result. The final pressure and velocity will depend on the relation between the area of the discharge area of the nozzle and of the throat.

When the back pressure is equal to or greater than the critical value the rate of flow of steam and consequently the velocity may be found from Napier's equation

$$M = (Fp_2 \div 42)\ \sqrt{3\ (p_1 - p_2) \div 2p_2}$$

where M is the weight of steam flowing per second, measured in pounds; F is the area of the throat in square inches; and p_1 and p_2 are respectively the initial and final pressure in pounds per square inch absolute.

When the back pressure is less than the critical pressure the flow is

$$M = Fp \div 70$$

When a venturi nozzle is used, the final velocity is a function of the heat drop through the nozzle.

Assuming frictionless flow and adiabatic expansion,

$$V^2 \div 2g = v\ (H_1 - H_2)$$

or $$V = \sqrt{2g \times v\ (H_1 - H_2)} = 223.7\ \sqrt{H_1 - H_2}$$

Actually, the effect of friction is considerable, amounting to from 10 to 20 per cent of the heat drop, and must be taken into consideration.

3. Disregarding radiation losses, that is, assuming adiabatic expansion through a reducing valve, there is a reduction in the heat content of the steam accompanied by an increase in the velocity of flow. This increased velocity is not maintained, however, because the energy of the jet is almost instantly dissipated as the steam mixes with that on the low pressure side of the valve and the final velocity is substantially equal to the initial. The velocity energy, caused by the expansion, is returned to the steam as heat so the final heat content is equal to the initial. Inasmuch as the pressure is less, the quality must increase. Where the steam is superheated in its initial condition, it will have a still higher superheat after passing through the reducing valve.

4. It is impossible to superheat steam in direct contact with water for the reason that steam has the same temperature as the water with which it is in contact and it tends to maintain this uniform heat level. If heat is added to the steam in an attempt to superheat it, there will be a flow of heat from the steam to the water which will be utilized to evaporate more of the water. There is, however, a considerable time lag involved and it is because of this that it is possible to superheat steam in an integral superheater which may not be more than a few feet from the boiler water surface.

Should Stoker Be Installed?

In answer to C. W.'s question on page 205 of the February 1 issue of Power Plant Engineering, in which he asks if it would be a profitable investment to install stokers on his three horizontal return tubular boilers:

It has long been a question whether or not stokers were economical in small plants. There are more small plants without stokers than there are with them, one reason for which is that most plants of this size are one man plants. Then again the question of initial cost must be considered. If you ask for stokers, the owner will want to know what the saving will be, and as you can not show saving in labor, he might say that with proper handling of the fires there would be no object in putting in stokers. No hand-fired boiler can compare in average efficiency with that of one stoker-fired, and a saving of 10 per cent should be made. A fireman may get some overload, say 30 per cent, while the stoker will handle over 100 per cent overload, hence if you were running three boilers usually, you could in emergencies use only two boilers.

In most of the new plants around here, where they have two boilers, stokers are being put in.

Springfield, Mass. L. N. Webster.

Central Station Service vs. Isolated Plant

In reply to the question submitted by O. P. I. on page 203 of the February 1 issue, I would like to suggest that the use of a Diesel or semi-Diesel engine may offer a solution.

The Diesel or semi-Diesel engine is coming into use more and more for this very purpose and is proving a decided saving over the steam plant in many cases. Exhaust gases contain a considerable amount of heat that can be effectively used to heat water for any desired purpose.

The utilization of an oil engine also cuts down labor costs as neither fireman, water tender or helper is required and the engine room force can as a rule be reduced to one man. Oil engines may be had in sizes as small as 100 hp. or as large as may be desired.

I have in mind a small plant used for supplying light and power in a small town in the Adirondacks where two low compression engines are used. One of these is a single-

cylinder 37-hp. unit and the other is a two-cylinder 75-hp. unit. This plant is run on three 8-hr. shifts, one man per shift.

My own observation has been that for small plants the low compression engine is better suited for the purpose and the full Diesel for higher capacities.

R. G. SUMMERS.

IN ANSWER to O. P. I. on page 203 February 1 issue of Power Plant Engineering, who is considering the proposition of substituting central station service for the isolated power plant which he is now using, I would say that this would depend on several things: First, does the factory require the use of boilers during the summer? Is the engine loaded during the winter? Do you have a minimum charge for power or do you pay for the amount that you actually use?

I have just been through this question and have decided to shut down the engine and use motors, as our boilers will not otherwise be required during the summer. It was decided that if we had no minimum charge and paid for only what we used we would run the engine in the heating season, but we had a minimum charge to meet and we would save more than enough in the summer to offset the loss in the winter, for there is no doubt in my mind that in the winter season the power does not cost a great deal, as most of the exhaust is used for heat in place of live steam; only about 10 per cent is used in the engine.

You could figure that in October 50 per cent of coal burned is used for heating; the rest for power. In November 75 per cent is used for heating and 25 per cent for power. In December, January, February and March 100 per cent is used in heating; the only loss here would be the loss of steam through the engine or about 10 per cent which is the generally accepted loss of steam heat through an engine. This shows that it would cost only a little more to run the engine in the cold months.

The cost of operating an oil engine for the year round job, for power alone would be more expensive than running a steam engine and using the exhaust for heating the buildings.

Springfield, Mass. L. N. WEBSTER.

Capacity of Boiler Stack

IN THE issue of Feb. 1, W. C. F. inquires as to whether or not he will have enough draft for 500 boiler horsepower of return-tubular boilers by adding 40 ft. to his present chimney, making it 150 ft. high.

I greatly doubt, for various reasons, that satisfactory results can be obtained by increasing the height of the old stack. It is unlikely that it is constructed heavily enough to carry the additional weight. This is particularly doubtful in regard to the foundation.

Assuming, however, that both wall thickness and foundation, are of such dimensions that they could safely carry the additional weight, the diameter of the increased stack would be so small that frictional losses would offset the gain from the increased height. In order to carry 40 ft. additional height, the top wall thickness of the present chimney should be at least 10 in. The clear diameter is now 4 ft. and the outside diameter is therefore 5 ft., 8 in. The additional column should have a taper of at least 4 per cent and the outside diameter at the top of the new stack would, therefore, be 4 ft. 1 in. (approximately). Deducting the wall thickness, which cannot safely be made less than 6 in., the clear diameter of the new stack would become 3 ft. 1 in.

It is recommended that he use a new chimney 150 ft. high and 4-ft. 6-in. clear diameter at the top; this size being taken from Kent's tables. Long experience has proven, that for a multitude of reasons the ratio of clear diameter to height of chimney above grade should be approximately 25. I would therefore recommend the use of a chimney 125 ft. high, 5 ft. clear diameter at the top. It will be noted that Kent rates the taller chimney at 551 hp. while the shorter and wider stack is rated at 632 hp.

It is perhaps also not without interest, that the 150-ft. chimney would cost approximately $5000 while the lower one would cost approximately $4000.

New York, N. Y. PAUL H. WALTER.

Are Traps Applicable Here?

WITH REFERENCE to W. J. M.'s query in the Feb. 1 issue, and with particular reference to his layout No. 1, it seems to me that there is possible a much more simple and economical handling of this case than by means of traps. I would suggest that he make use of his present equipment but endeavor to arrange his pump so that it will handle the hotter returns.

Judging from the sketch, the return pump is probably on about the same level as the hot well, which accounts for its inability to handle water much hotter than 190 deg. My suggestion would be that he arrange to lower his pump by putting it down in a pit, so that the returns from the hot well will fall to the pump with sufficient gravity head so that the water will follow the pump plunger. That is the whole secret of handling hot water with a pump; that is, having a positive head of water on the pump, to prevent the flashing of the hot water into vapor, which is the case where the pump plunger creates a suction.

Hot water can be pumped without difficulty if the following precautions are observed: 1. have a positive head of water following the pump cylinder to eliminate any possibility of the pump having to "suck" the water; 2. operate the pump so that the plunger speed will not be so high that the water cannot flow after it; 3. lighten the springs on the suction valves so that they seat lightly; 4. insure having a generous size pipe between the hot well and pump. If his pump is properly installed and operated, W. J. M. can handle hot water satisfactorily and I believe this arrangement would be a more satisfactory one than attempting to work a series of return traps. M. A. S.

Economy of Exhaust Heater

WE HAVE a 24 by 54 by 36-in. cross compound engine running at 40 r.p.m. which develops, under normal load, about 500 hp. using about 15 lb. of steam per hp.-hr. with a vacuum of 26 in. Our boilers evaporated 230,000 lb. of water in 24 hr.

By using a heater between the low pressure cylinder and the condenser, we are able to increase our feed water temperature from 180 to 200 deg. F. but at the same time, on account of leaks in the heater, we reduce our vacuum to 23 in. Do we gain or lose by using the heater?

An opinion on this question from brother engineers would be highly appreciated. W. T.

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Keep the Mines Working

Nobody who has had to buy coal for any industrial or public utility concern will question the statement that the bituminous coal mining industry is in a deplorable condition. For years there have been periodic threats of strikes among the miners with an occasional total cessation of operations accompanied by rapid fluctuations in prices and uncertain deliveries. In fact every conceivable inconvenience that a purchaser of raw material can encounter has been heaped upon the purchaser of coal.

April 1 is the date set for a renewal of the contract between the coal mine operators and the United Mine Workers. The miners are taking the sensible attitude of not asking for an increase in wages but are attempting to secure a renewal of the present wage scale for a term of four years. What the results will be cannot easily be predicted. What the coal consuming industries want is coal, delivered according to prearranged contracts and at prices that are reasonable and dependable.

Many authorities share the opinion of Secretary Hoover that continuous, smooth operation of the mines over a term of years without interruptions due to strikes, lockouts and car shortages which result in coal famines to the consumers, accompanied by outrageous prices would result, by the ordinary procedure of competition, in the elimination of producers who depend upon famine prices. The country has 30 per cent more coal mines than are required by the demand for coal with an equal over supply of miners, who, though actually working but a portion of the time, demand wages that will support them over long periods of idleness. These conditions have been built up by unnatural control of wages for labor and prices for coal.

Continuous operation would render the business of the lower-cost operators more stable and the prices of coal would be lower because the surplus of mines and labor are a charge on the consumer in the end. Transportation difficulties seem to be on the decrease, judging from the service of the past year, so the principal hindrance in the way of continuous operation is the employment relationship between the mine operators and miners.

Buyers of coal have a function to perform in bringing about a betterment of conditions in the coal mining industry. By distributing the delivery of coal over the entire year making up the 60 to 90 days storage requirements during the spring and summer months, much of the irregularity in production can be averted, if the miners are kept on the job. Although it may cost something to keep them there, the cost will be greater if they strike, and continuous operation will give opportunity to bring conditions to a normal state. The power plant industry should give all reasonable co-operation to keep the mines running continuously.

Diesel Engine Lubrication

Probably no more difficult problem exists in the field of lubrication than that for the Diesel engine. It is not, however, a problem which cannot be solved successfully, if the operating engineer will study the problem and employ good practice for its solution. The problem involves high working pressures on journals and bearings, air compressor cylinder lubrication, combustion engine cylinder lubrication and the maintenance of a somewhat elaborate system for the distribution of the lubricant.

Method and point of application must be given careful consideration. An oil which will give satisfaction, if applied at the proper time, place and in the right quantity, will be declared unsuitable, if the lubrication system is faulty or inadequate. Lubricants which, under favorable conditions, will well serve their purpose may suddenly appear to have become unsatisfactory. In this case, it is reasonable to assume that the oil is not necessarily to blame but that the lubricating system has not been maintained in proper operating condition and that some condition has arisen which is seriously interfering with the use of that oil.

In any case of lubrication trouble, it will be advisable first to be satisfied that the lubricating system is adequate, that it is properly installed and that it is in good operating condition. This establishes a sound working basis upon which to try out different lubricants.

Discussion, in this issue, on the lubrication of Diesel engines will help to analyze the conditions to be met, find the causes of failure and devise the means by which lubrication troubles may be overcome.

Variable Voltage Elevator Control

Ever since the general acceptance of the alternating current system, the subject of electric elevator control has received much discussion. Low-speed electric elevators using direct-current motors were in use as early as 1890. Later, when taller buildings necessitated higher elevator speeds, the direct-current motor was developed to take care of the situation, and for years has given excellent satisfaction in this field. The direct-current motor is efficient and its inherent speed control characteristics adapt it almost ideally for elevator service.

With the growing use of central station power, efforts were, later, directed towards applying the alternating-current motor to elevator service, but this attempt was not so successful. While the alternating-current motor has certain advantages over the direct current motor so far as simplicity of construction and maintenance is concerned, its speed control characteristics are poor. The electrical engineer, however, is not easily discouraged and in spite of the inherent shortcomings of the alternating-current motor he has, in recent years, overcome many of the obstacles which prevented its application to elevator service. Speeds of 540 ft. per minute with alternating-current motors have been entirely successful and a considerable amount of success has been attained in applying them to even higher speeds.

In spite of the successful application of alternating-current motors to elevator service and without discounting future success in this direction, the fact remains that the direct-current motor is still the most satisfactory device for high-speed service, particularly where speeds of over 550 or 600 ft. per min. are desired.

Perhaps the most flexible system of d. c. elevator motor control is that in which each motor is supplied by its individual direct-current generator. This generator may be driven by either an a. c. or a d. c. motor, so the system lends itself admirably to buildings in which only alternating current is available. With this system, the field strength of the generator is varied in order to obtain various motor speeds. When the generator is properly designed, the elevator motor may be operated from rest to full speed in either direction by changing the strength and direction of the generator field. This system of control will permit an acceleration from rest to 600 ft. per min. in very close to two seconds. The a. c. driving motor, that is, the motor driving the generator, may be a synchronous motor adapted for power-factor correction where conditions require such an arrangement.

The power required when starting and when operating at low speeds with the variable voltage system of control is less than with the rheostatic system in the proportion that the generator voltage bears to the voltage of the line supplying the motor generator set. For instance, if the generator voltage is 25 per cent of the line voltage, the elevator motor can draw approximately four times its full load current without exceeding the full load demands from the line. This is particularly valuable where the source of power is alternating. In fact, with this system, the power demand during acceleration may be less than full load.

So in spite of its seeming complexity, this method of control has much to offer. Speeds of 700 ft. per min. are in use and for this class of service, the variable voltage control system has met with great success.

Engineers having to do with electric elevators will find much of interest in a study of this system and their attention is directed to the article by Edgar M. Bouton on this subject which appears in this issue.

Full Time Efficiency

To obtain the most satisfactory and efficient operation of a boiler plant, it is imperative that good practice be put into force for the full time that the plant is in service.

Conditions are not right in any plant when the day crew establishes a good record of operation only to have it offset by haphazard and indifferent methods of men on the night shift. In most of the cases where this condition prevails an explanation may be offered that smoke ordinances hold a check upon wasteful practices during the hours of daylight. It is during this period that violations of the law are most likely to be detected. Under the cover of darkness the best interests of all concerned are overlooked simply because the men do not comply with the law when they feel that they are not being watched. This is but an instance of the condition which has become a criticism of the times, namely that there is an alarming disrespect for the law.

What is the effect of this attitude? In the first place, it is contributing to discomfort, ill health and property damage in the community and, second, it shows that the men in charge of these plants are neither giving the best to those by whom they are employed nor to the community in which they reside.

This is a condition which is difficult to change and it is probable that it can be overcome only by keeping a strict record of night operation and making direct appeal to the operators' personal pride and their sense of respect and justice towards the community.

BEFORE the days of modern instruments the engineer was compelled to judge the efficiency of his furnaces by the steam pressure gage and his practical knowledge of how a fire should look. Sometimes he guessed right; more often he wasted coal. The modern engineer calls upon chemistry and instruments for analyzing the products of combustion, to guide him in building furnaces and firing coal. Science guides him. Practical results verify each step. He knows he is right.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Work on Kearny Plant Progressing

PLANT TO BE OPERATED BY THE PUBLIC SERVICE ELECTRIC CO.
WILL ADD NEW LINK TO CHAIN OF SUPERPOWER STATIONS IN EAST

ADDITIONAL details are now available concerning the Kearny Power Plant which is being built by the Public Service Electric Power Co. for lease to the Public Service Electric Co., as noted in the Nov. 15, 1923, issue of Power Plant Engineering. Construction of this plant was started on July 16, 1923, and is progressing favorably, as may be seen from the accompanying illustration which shows the state of the work early in January. A view of the completed station, made up from a drawing, is also reproduced.

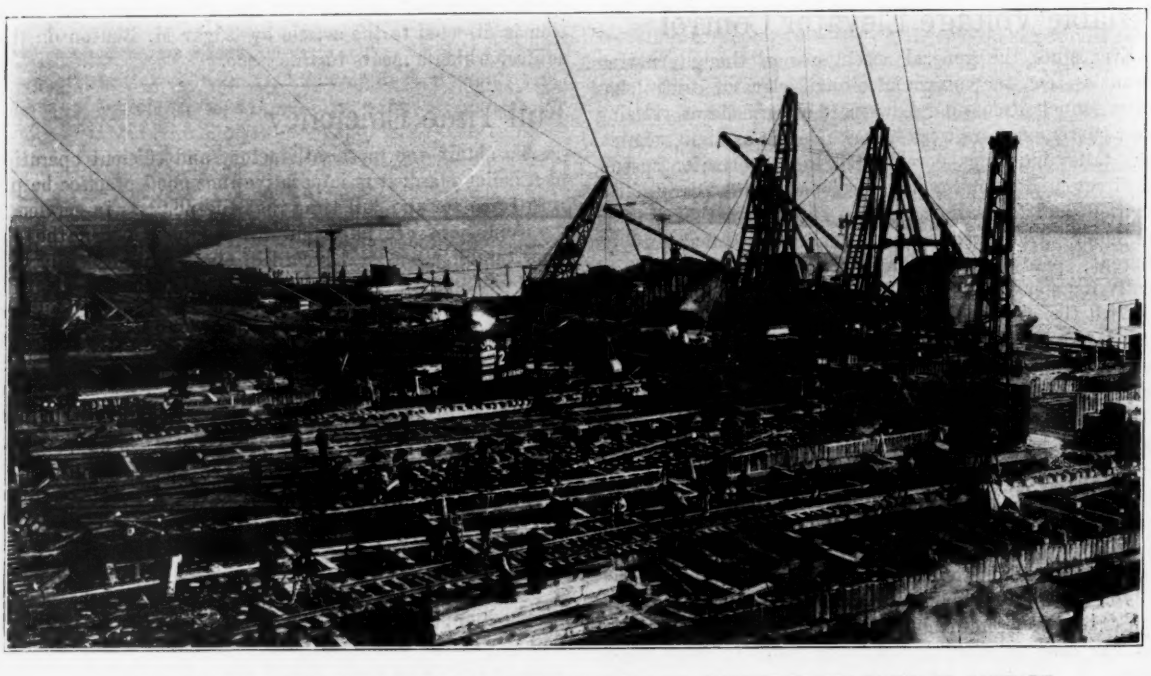


FIG. 1. VIEW SHOWING PROGRESS IN CONSTRUCTION OF KEARNY PLANT EARLY IN JANUARY

The first section of this station, comprising half of the ultimate capacity of 410,000 kv.a. at 80 per cent power factor, will be ready for service in 1925, at a cost of approximately $20,000,000. The Public Service Production Co. is the general contractor. The site of approximately 100 acres lies on the Hackensack River, about midway between the Essex and Marion stations, the latter being located on the east side of the Hackensack and the former on the west side of the Passaic River. Questions of space available or limitation of circulating water supply did not enter into the determination of the ultimate capacity of the station, which was fixed by engineering judgment of the most efficient size of plant.

Arrangement of buildings includes coal bunker on the river front and parallel with it, with the boiler house, turbine room, and switch house in rear, in the order indicated, and an outdoor substation adjacent to the switch house. This arrangement shortens on the one hand the travel of coal received by way of the river, and on the other hand the length of generator leads and control wire.

Foundations for the section now under erection require 22,000 piles, 36,000 cu. yd. of concrete, and 1,500,000 lb. of reinforcing steel; and the construction weight will be about 220,000 T., or roughly one ton per kv.a. capacity. The main buildings will have 225,000 sq. ft. floor space and 10,000,000 cu. ft. volume. In their construction, 12,000 T. of steel and 7,000,000 brick will be employed.

Practically the entire site not used for buildings or for outside substation purposes will be devoted to coal storage, with an ultimate capacity after completion of filling which is contemplated, of 375,000 T. Coal may be received simultaneously by rail and river. The equipment includes a

coal tower of 350 T. per hr. capacity, an unloading pit where four railroad cars can be emptied at once, complete drag scraper equipment and system of belt conveyors, so that coal received from the two sources can be distributed to both storage piles and station bunkers, coincidentally.

Ash handling will follow the general lines laid down in the Hell Gate installation, the refuse being delivered through clinker grinders to a sluicing trough underneath the boilers and washed by streams of water into ash pits located outside the building. From this point, it will either be pumped to other parts of the property where it is wanted for fill, or loaded on railroad cars or barges for removal.

Steam will be generated in B. & W. boilers having a rating, based on heating surface, of 2360 hp. each. There will be superheaters between two banks of tubes, but no economizers. Superstokers of Riley and Taylor types, about seventeen feet long, will be employed. The Riley stokers will have fifteen retorts and the Taylor stokers sixteen retorts each. Air supply to each stoker will be by means of a forced-draft fan designed to deliver 135,000 cu. ft. of air per min. at a static pressure of 7 in. In addition, there will be an induced draft fan for each boiler, having a capacity of 275,000 cu. ft. of air per min.

Construction of furnace walls over the fire belt will be such as to permit renewal of fire-brick without interfering with the remaining brickwork.

As previously stated in these columns, three of the main turbo-generator units will be General Electric Co. 39,200-kv.a. machines, and two Westinghouse 43,750 kv.a. with turbines designed for 325 lb. and 700 deg. F. at the throttle. All auxiliaries will have electric drive, with power derived from the main units, a. c. being used, except that the following will be steam driven, for emergency service—boiler feed pumps to keep boilers in line without load in case of interruption of electric auxiliary service. one circulating pump connected for use on either of the five units, and one condensate pump for each unit.

Each turbine will exhaust to a surface condenser of 50,000 sq. ft. condensing surface, supplied with circulating water by two pumps having a combined capacity of 75,000 to 80,000 gal. per min. The ultimate requirements for ten surface condensers will therefore be in the neighborhood of 800,000 gal. per min. There will be a circulating water intake perpendicular to the river front for each condenser. The discharge tunnel will be parallel to the river front and will ultimately discharge at either end into the river. Means will be provided to force the discharge in the direction of the tide and prevent it from flowing back through the intakes.

Heat balance will be maintained by bleeding each main turbine at four points for the purpose of feed water heating. The net economy in B.t.u. per hr. predicted for the station is about 16,500.

Current generated at 13,800 v., 60 cycles, three-phase, will be stepped up to transmission voltage at the outdoor substation through five banks of 45,000-kv.a. transformers, each transformer bank consisting of three 15,000-kv.a. single-phase self-cooled units connected delta on the low tension side and star on the high tension side. The high tension outdoor busses will be arranged so that any number of transformers can supply power to any of the transmission lines. There will be a double high tension bus and several spare line oil circuit breakers. Eventually, a high tension transfer bus will be provided so that the future bank of spare transformers can be connected to any line to take care of a possible failure of any bank of transformers.

The oil circuit breakers for this installation will have a rupturing capacity of 1,500,000 kv.a., the maximum capacity manufactured to date. All the disconnecting switches, with the exception of those used with lightning arresters, will be operated by means of 250-v. d. c. motors.

Besides a two-circuit tower line between Kearny and Essex Stations and another between Kearny and Marion Stations, two or more tower lines leading from the outside substation to other points are in prospect. The 13,800-v. switching equipment is to be located in a separate building about 25 ft. away from the turbine room. All the generators will be tied through ten per cent tie bus reactors to the group tie busses, which will in turn be connected to the main tie busses through four per cent reactors.

Phase segregation will be carried out according to the vertical system, with phase 1 on the first floor, phase 2 on the second, and phase 3 on the third. The fourth floor will accommodate the operating mechanisms for oil circuit breakers and for gang operated disconnecting switches. Control room and conduit room will be located about the center of the completed switch house, above the fourth

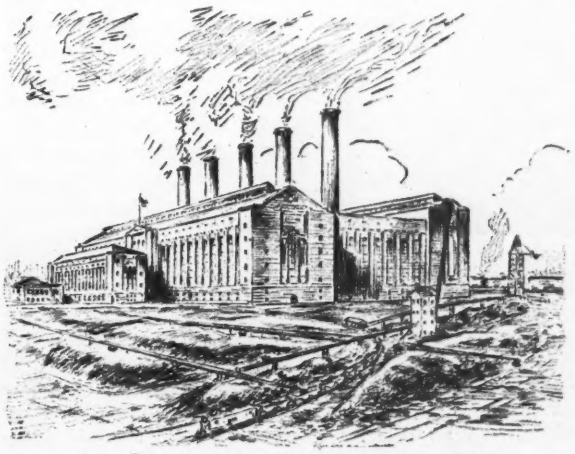


FIG. 2. DRAWING OF COMPLETED STATION

operating floor. The rupturing capacity of all oil circuit breakers in the switch house will be the same as that of the outdoor circuit breakers, 1,500,000 kv.a.

A transfer bus will be provided for the purpose of transferring any generator to any other bank of transformers instead of the transformer bank regularly assigned to it.

Power for station auxiliaries will be fed from the main tie busses through three banks of 7500-kv.a. single-phase transformers and stepped down to 2300 v. three-phase. Two main tie busses are provided to give the maximum reliability to the station auxiliary load. All the generators will be operated in parallel through the group tie busses, and the various groups tied together through the main tie busses. The main auxiliary substation supplying three-phase power at 2300 v. and 440 v. for the operation of station auxiliaries will be located in the turbine room basement. Control panels with their oil circuit breakers will be of the truck type. Four types of motor will be employed for auxiliary drive, as follows:

First: Squirrel cage motors with rotors having a double squirrel cage winding.

Second: Squirrel cage motors with rotors having a single winding.

Third: Synchronous motors.

Fourth: Induction motors with wound rotors.

A. I. E. E. Convention a Big Success

POWER TRANSMISSION WAS THE PRINCIPAL TOPIC AT THE RECENT PHILADELPHIA CONVENTION

OF PARAMOUNT interest, among the many technical sessions held at the twelfth mid-winter convention of the American Institute of Electrical Engineers at Philadelphia, Feb. 4—8, were those devoted to the discussion of superpower problems. An unusual amount of interest was exhibited in this phase of electrical engineering and the sessions devoted to the subjects were exceptionally well attended.

In opening the first session on Monday afternoon, President Harris Ryan touched briefly upon the super power and transmission problems which are awaiting solution today. He called attention to the necessity of building "bridges" to span the empty spaces between the sources of power and the market places. The bridges are our power transmission lines, and while the building of these lines requires much careful study, the structural details are comparatively simple matters. President Ryan indicated the necessity of standardizing on a nation wide voltage if we are to have a nation wide network of transmission.

As 1924 was the 40th year in the life of the Institute, it was fitting that the 40th anniversary should be celebrated at this meeting. On Monday evening, the opening day of the convention, a celebration was held to commemorate the 40th anniversary and in honor of John W. Lieb to whom the Edison medal was presented.

At this occasion Elmer Sperry, Elihu Thomson, and T. C. Martin, spoke of the activities of the Institute in its early days.

Mr. Sperry spoke of the birth of the Institute—how two separate groups of men, one in the East and one in the west, conceived the idea of forming a society or an association of "electricians." Norvin Green, president of the Western Union Telegraph Co., was elected the first president of the Institute.

Mr. Sperry's talk was followed by one by T. C. Martin in which he related interesting incidents of the early days. At that time the Institute was so small that meetings were often held in restaurants.

Dr. Elihu Thomson referred to the development of the electrical art in the early "eighties" and told of the limitations under which the electrical engineers of those days worked.

Another speaker, although not one of the founders of the Institute, was J. J. Carty, who traced the growth of the electrical industry to its present high state of development. He laid particular emphasis upon the importance of the electrical engineer's contributions to modern civilization.

Immediately after the celebration of the 40th Anniversary, the Edison medal was presented to John Lieb by President Ryan. Samuel Insull told of his years of personal and professional association with Mr. Lieb and lauded his accomplishments in the development of the light and power industry. He particularly emphasized the importance of Mr. Lieb's work in the application and development of the incandescent electric lamp.

Presentation of the medal was followed by a response from Mr. Lieb, who reviewed the work and accomplishments of the electrical engineer and pictured the future development of the art. He alluded to the systematic and scientific methods which characterized the growth of the electrical industry—how fundamental principles and laws were developed in the great research laboratories of the country and then applied to commercial practice.

As super-power transmission problems are foremost in the minds of electrical engineers today it was quite natural that the convention should begin with papers dealing with this problem, the first of this group was presented by Percy H. Thomas, consulting engineer of New York. This paper was entitled, "Superpower Transmission Economics and Limitations of the Transmission System of Extraordinary Length."

Mr. Thomas pointed out that the present day tendencies and developments are for high voltage, long distances and greater power. He assumed a superline which he stated is of an ambitious capacity, but still an entirely feasible one for our present day knowledge and upon this superline he made calculations to prove this assertion. He used as a basis a 500-mi. line delivering regularly 400,000 kw. on lines insulated for 250,000 v., 60 cycles.

Other studies of long distance power transmission were made and C. L. Fortescue and C. F. Wagner, both of Westinghouse Electric & Mfg. Co. presented mathematical calculations to develop further use and properties of the circle diagram. They endeavored to show how the characteristics of the synchronous condenser limit the maximum power that can be transmitted over a line. They also made comparisons of a 500-mi. straightaway line with 500-mi. line with condenser at mid-point.

"Power Limitations of Transmission Systems" was presented by R. D. Evans and H. K. Sels, several items of limitations were dealt with in this paper. The authors recommended that a single line should be less than 250 mi., and longer lines be loaded at intermediate stations with synchronous condensers so that no section exceed 250 mi. "Stability of Power Transmission" was studied by R. D. Evans and R. C. Bergvall. Such phases as the 500-mi. straight line, also the mid-point of this line were dealt with from an experimental analytic standpoint. A paper on "The Limitations of Output of a Power System Involving Long Transmission Lines" was presented by E. B. Shand of the Westinghouse Electric and Manufacturing Co. He made mathematical analysis to cover different conditions determining limits of output. A numerical example of a 300-mi. line was considered and various characteristic curves drawn. Unlike the other papers presented dealing with limitations Mr. Shand used vector relations in his curves, and it was pointed out that if we are going to have a general power system it is necessary to have a constant transmission, having a straight line relation of changing current.

Miss Edith Clarke, of the General Electric Co., presented a paper and discussed the possibilities of the long line; she made curve studies of the 500-mi. line and compared it with the 250-mi. line.

In the discussion, Mr. Thomas' proposed long distance line and the other papers above mentioned were questioned by several present, these criticisms were about all of the same nature, i. e., fear that the limits of these studies are set too high for practical purposes. The chief complaint was that all of these calculations were made on a steady static basis and not sufficient consideration was given to transient loads, stability of switching, behavior of condensers during load changes, limitations of generators, synchronous transformers at receiver ends and that these calculations should be made on a basis of irregularities rather than a basis of regular applied loads.

In the rebuttal of the authors of this group of papers it was pointed out that most of the complaints were borne in mind when the papers were prepared but due to the tremendous amount of detail description and calculations necessary to clear up these points they were omitted on account of length of papers. Also it was stated by Mr. Thomas that, due to this being such a large problem, he does not think it can be properly criticized before it is thoroughly studied and digested. The speaker stated that the suddenly applied loads will not affect such a system as he has proposed as he has all lines connected to different points in the system, so that a local disturbance will not affect any other part of the system, all generators are parallel, all condensers are on same bus and the objectional points about the apparatus will be easily overcome.

In summing up all objections to these proposed systems of long distance transmission F. G. Baum who presided over this session stated that stability is becoming more and more simplified, and it is not possible to have such serious transient conditions. When necessity demands, we shall surely be able to take power from places where "it is" to places where "it is not" wherever those places may be.

On Tuesday morning the discussion of more detail matters began and continued to the end of the convention with the exception of the transportation session.

Tuesday afternoon and evening were given over to a discussion of the electrification of railroads. President Ryan, in opening this session, brought out the point that before the problems confronting the railroads can be solved, there must be a more intimate contact between the technical and practical men of both electrical and railroad industries.

Two subjects of vital importance in elevator engineering both electrically and mechanically were discussed, first, "Transient Performance of Electrical Elevators" by D. L. Lindquist and E. W. Yearsley, and second, "Variable Voltage Elevator Control Systems applied to Elevators" by Edgar M. Bouton. The latter paper appears in another section of this issue.

In discussing the system of variable voltage control it was pointed out that there is a disadvantage in the use of so much rotating machinery, and it was proposed to eliminate this by a motor with a flywheel connected across the line. Mr. Bouton, however, could see no real advantage in the scheme.

A. L. Penniman, Jr., presented a paper on "Power Plant Auxiliaries and Their Relation to Heat Balance." In this paper he brought out that motor-driven auxiliaries receiving their power from auxiliary turbogenerators, the exhaust from which is used for heating feed water is a reliable and economical system but is handicapped by the fact that over a considerable range of load some of the auxiliary power must be taken from the main bus or some of the energy generated must be fed to the main bus. He said greater economy lies in the use of power from the main unit for auxiliary drives, this power being applied as directly as possible, together with the use of the maximum economical amount of low-temperature steam bled at several points from the main unit. The question was raised as to the flexibility and ease of operation of this system, the author stated that stage bleeding together with electric drive offers opportunity for higher efficiency with a maximum of flexibility at a cost as low or lower than with any other forms of auxiliary drive.

On Wednesday, a feature of importance was the dedication of the Moore School of Electrical Engineering at the University of Pennsylvania.

On Thursday evening, a dinner dance was held at the Bellevue-Stratford. The total attendance at the convention was 1579.

Elihu Thomson Awarded Kelvin Medal

PROF. ELIHU THOMSON, one of the founders of the General Electric Co., and among the world's most eminent electrical engineers, has been awarded the Lord Kelvin gold medal and will go to England during the coming summer to receive it, July 11. The award was made by British and American Engineering Societies acting jointly. It is awarded every 3 yr. as a mark of distinction and for excellence in original research work in engineering. Prof. Thomson is the first American to receive this honor.

Professor Thomson became Professor of chemistry and physics in the Central High School in Philadelphia in 1876, the centennial year. Being interested, in early life, in electricity, he began work in dynamo and electric lighting development while teaching. The result of the work was the establishment of the American Electric Co. in New Britain, Conn., devoted to the construction of the Thomson-Houston electric arc lighting system, which had features which made it preferable to others, especially its possession of an automatic regulator. The interests were brought to Lynn more than 40 yr. ago by Charles A. Coffin, a prominent shoe manufacturer who later became president of the General Electric Co., and only recently retired from this position, Henry A. Pevear, Patrick Lennox, W. Scott Dixon, J. N. Smith, B. F. Spinney, and other Lynn shoe and leather men, who formed the original Thomson-Houston Electric Co., to introduce the electric lighting system. Their venture met with immediate success and the lamps of the system were soon seen burning in almost every important city and town in the country.

In the course of time, Prof. Thomson solved mysteries of electricity, other than that of the motor, and opened the way to put them into practice in everyday occupations. For his skill and success in this work he is now awarded the Lord Kelvin medal, which is one of the most highly regarded trophies of the world of science.

Prof. Thomson has been granted about 700 patents in the United States. His inventions in dynamo electric machinery, electric welding, watt-hour meters, lightning arresters and magnetic arc extinguishers are fundamental. He was a pioneer in arc lighting and innumerable electrical devices have been improved through his work.

He has received the honorary degree of Master of Arts from Yale; a Doctor of Philosophy from Tufts, and of Doctor of Science from Harvard, and has been decorated as a Chevalier et Officier of the Legion D'Honneur of

France. For his achievements in the electrical field he was awarded the Grand Prize at the Paris Expositions in 1889 and 1900 and the St. Louis Exposition of 1904. He was president of the American Institute of Electrical Engineers in 1889 and the first recipient of the famous Edison Medal. He has been awarded the John Fritz medal of the four national engineering societies, the Hughes medal of the Royal Society of London, the Rumford medal, the Eliott Cresson gold medal by the Franklin Institute, and twice received the John Scott Legacy medal for electrical inventions.

Always interested in education, he is now, and has been for many years, connected with the Managing Corporation of the Massachusetts Institute of Technology, and was the acting president of the Institute from 1920 to 1922 inclusive.

He is a member of various American and British scientific and professional societies.

Large Power Plant Planned Near Macon, Ga.

EQUIPMENT FOR the first unit of a new $3,000,000 electric steam power plant for the Central Georgia Power Co. has been ordered and the work of erection will commence in July, according to an announcement by L. A. Magraw, manager of the company. This station will be located on a 22 acre tract two miles north of Macon, Ga. The first unit will have a capacity of 13,000 hp. The site is on the Emory Winship property which was acquired by the Power Co. last December, and lies between the Ocmulgee River and the Southern Railway. Ample trackage facilities and water supply is therefore insured.

Mr. Magraw states that the plant will be ready to deliver current in March, 1925. It will be owned by the Central Georgia Public Service Co. but will be leased and operated by the Central Georgia Power Co.

In addition to the 13,000 hp. that will be produced as soon as the first unit of the steam electric plant is completed, the Central Georgia Power Co. is buying 55,000 hp. There will be five units to the new plant when it is completed.

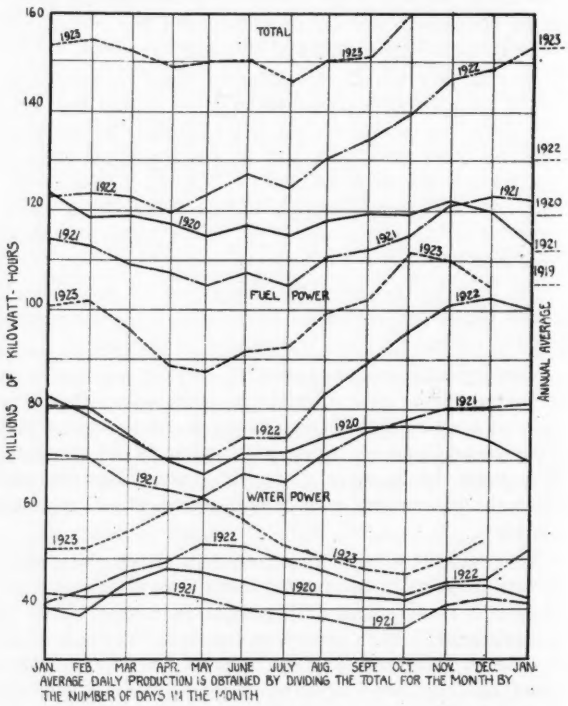
Production of Electric Power Increases 17 Per Cent

REPORTS FROM the Department of the Interior, U. S. Geological Survey, indicate that the total production of electricity by public utility power plants for 1923 was 55,928,000,000 kw.-hr., an increase of more than 17 per cent over the output in 1922. The output in kilowatt-hours for each of the past five years and the per cent produced by water power were as follows:

1919.....	38,921,000,000	kw.-hr.....	37.5%
1920.....	43,555,000,000	kw.-hr.....	37.1%
1921.....	40,976,000,000	kw.-hr.....	36.5%
1922.....	47,659,000,000	kw.-hr.....	36.1%
1923.....	55,928,000,000	kw.-hr.....	35.1%

These figures indicate that water power apparently is not holding its own as the percentage has decreased from 37.5 in 1919 to 35.1 in 1923. The production of electricity by the use of water power, however, is dependent upon the amount of water available for use of water-power plants and serious droughts have occurred in the past two years in different sections of the country which have materially affected the flow of the streams in those sections, which has reduced the utilization of the full capacity of water-power plants. A season of normal or abundant water supply for the entire country would have a direct effect upon the output of electricity by water power at public utility plants.

In 1923 the amount of electricity produced by the use of water power at public-utility power plants would have required the consumption of about 23,500,000 tons of coal. This is equivalent to nearly 1300 car loads per day.



CURVES SHOWING PRODUCTION OF ELECTRIC POWER 1920-1923

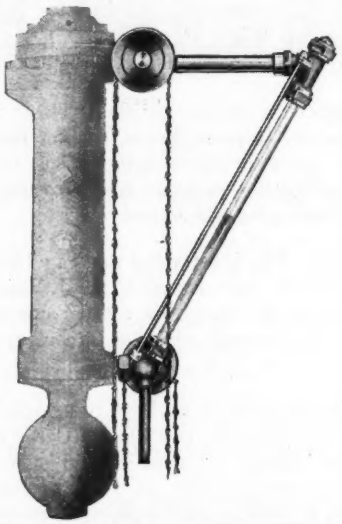
There was a small increase in the efficiency in utilization of fuel during 1923 as compared with 1922, as the average rate of consumption of coal in 1923 was about 2.4 pounds per kilowatt-hour as compared with 2.5 pounds in 1922. Even this small gain is equivalent to 1.8 million tons of coal during the year.

Water Gage for Use With High Settings

WITH THE high boiler settings used in present day practice it is often difficult to locate the water column so that it may be seen easily from the operating floor, especially in cases where the firing aisle is narrow. This obviously is an important detail, as the boiler water level is the most vital variable in the entire power plant and must be watched continually. Uncertain vision with regard to the water gage is liable to introduce an element of danger into the plant which nobody can afford to ignore.

To overcome this condition, and therefore to minimize the chances of damage to the boilers, there has been developed an inclined gage which permits the water level to be

seen easily from any point on the operating floor. This gage which is shown in the accompanying illustration exposes the water level itself to the direct view of the attendant without employing reflected rays and without the use of prisms.

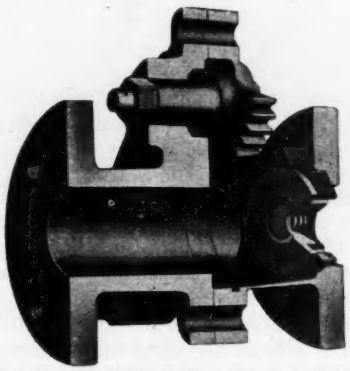


SESURE WATER GAGE MAKES WATER LEVEL VISIBLE FROM ANY POINT ON THE OPERATING FLOOR

This device is adaptable to any type of water column and is designed for all pressures and steam conditions. It is manufactured by the Sesure Water Gauge Co., of New York City.

New Schiller Blowoff Valve Does Not Clog

SOME EXTREMELY desirable features are incorporated in the new Ever-tight blowoff valve recently placed on the market by Joseph F. Schiller, of Philadelphia, Pa. This valve, as may be noted, is of the lever



SECTIONAL VIEW OF THE SCHILLER EVER-TIGHT VALVE

operated type in which a sliding member opens and closes the valve. The sliding member is so constructed that in passing from the opening to closing position the fluids and particles of solid matter blow straight through the sliding member as if it were a continuous pipe, and never comes in contact with the valve seat. The sliding member is a geared rack of bronze and has inserted in it a loose valve disc of bronze with a spring between the sliding rank member and the valve disc. The only duty the spring performs is to keep the valve disc against the seat when there is no pressure. There are holes through the sliding rack member which allows the pressure to act on the flange of the valve disc. This disc is forced tight against the valve seat, making the valve tight and thus equalizing its pressure upon the seats. The sliding member is so balanced that the valve works easily under all conditions of pressure, and is not too quick on opening or closing to do any damage to pipe fittings on the outlet side of the valve. There is therefore no friction, consequently no wear. The sliding rack is also provided with projections on the ends and are adapted to engage the casing and break up any encrustation which may form thereon, and acts as stops in the opening and closing of the valve, making it anti-clogging.

As may be noted, the valve is made in two parts, which are bolted together upon a gasket. All the working parts are bronze fitted. The design and construction of the Ever-tight valve is such that it can be used for almost any commercial purpose—steam, water, oils or acids. It can be obtained in sizes from one inch to 12 in.

News Notes

WARREN WEBSTER & Co., of Camden, N. J., has moved into its new plant at Federal and Seventeenth Sts., Camden. While the move was made necessary by the fact that the former plant is on the site taken for the new Camden-Philadelphia bridge, now under construction, improved facilities have been provided and allowance made for extension. The new plant was constructed by the Austin Co., of Cleveland, with the Ballinger Co., of Philadelphia, as advisory architects. It consists of a two-story building, with stock and shipping rooms on the first floor and offices on the second floor. Adjoining the rear of this building is the manufacturing plant of monitor construction. Extensive laboratories devoted to the company's experimental, research and test work are an interesting feature. The heating system of the plant itself has been so designed that it also can be used in connection with experimental tests.

HEINE BOILER Co., of St. Louis, Mo., announces the following change in its sales representation in the State of Texas. The Tennant Co. with offices in the Union National Bank Building, Houston, will represent the company in a new territorial division comprising the entire southern half of the State of Texas. J. A. Tennant is in charge of this office. Smith and Whitney, of Dallas, Texas, will continue representatives in the northern half of Texas.

YEOMANS BROTHERS Co. of Chicago, has recently established the following new district sales agencies. Toledo, Ohio, A. Carle Rogers, 752 Euclid Ave., covering the northwestern Ohio.

Seattle, Washington, Godfrey Jones Co., 2021 L. C. Smith Building, who will represent the company in central and northwestern Washington.

STAGG & HUNGERFORD, wholesale distributors of anthracite and bituminous coal, have opened offices in the Whitehall Building, New York. Mr. Hungerford was formerly sales manager for the Files Engineering Co. at Providence.

EUGENE L. FALLON, formerly with the Aluminum Co. of America, as Assistant Electrical Superintendent of the Niagara Falls plant, is now engineer in the Electrical Division of Stone & Webster, Inc., Boston, Mass.

McClellan & Junkersfeld, Inc., announces the removal of its Home Office to 68 Trinity Place, New York, N. Y.

The Girtanner Engineering Corporation announces the appointment of Horace Mann Mfg. Co., of 122 Third Street, Muskegon, Mich., as district representative for the State of Michigan.

American Schaeffer & Budenberg Corporation has acquired the important assets including patents, trade marks, trade names and good will, of the firm of Hohmann-Nelson Co., Eau Claire, Wis.

J. B. Engineering Sales Co., Connecticut sales representatives of the Conveyors Corporation of America, 326 W. Madison St., Chicago, has moved its office from Hartford to Chamber of Commerce Building, New Haven, Conn.

The Consumers Power Co. has purchased the system of the United Electric Co., which serves communities in Calhoun and St. Joseph Counties, Michigan. Existing transmission lines will be rebuilt and the 40,000-v. line from Battle Creek will have capacity for the whole district.

Robert L. Sheraton has been elected a Vice President of the Continental Valve and Equipment Co., with headquarters at the factory in Framingham, Mass. Mr. Sheraton was formerly assistant to the president of the Edward Valve & Mfg. Co.

Catalog Notes

Schutte & Koerting Co., of Philadelphia, has issued a general catalog of industrial and power plant appliances. This takes the form of a well constructed binder in which are collected all the bulletins on the subject issued during the past few years.

These bulletins describe the various types of equipment which the company manufactures and are illustrated with numerous colored diagrams. These colored diagrams are extremely effective in making the action of the devices clear.

Some of the devices described are as follows: Injectors, steam jet syphons, water heaters, undergrate blowers, blast nozzles, venturi stacks, steam jet exhausters, condensers, relief valves, separators, spray nozzles, valves, strainers, oil coolers, etc. The bulletins are fitted into the binder by means of a novel loose leaf arrangement which permits bulletins to be added or removed from time to time.

Griscom Russell Co., of New York City, has published Bulletin 1216 describing the U-fin Air Cooler. The apparatus is designed for cooling the air from the windings of electric generators by means of the condensate from the turbine condenser. This is a relatively new development in power plant engineering and serves the double purpose of cooling the air and at the same time heating the water.

Engineers interested in hydroelectric projects will be interested in Bulletin No. 1127, just issued by the Allis-Chalmers Manufacturing Co., of Milwaukee, Wis. This bulletin is devoted to a description of various installations of water wheel generators made by the company and is fully illustrated.

The Martindale Electric Co., of Cleveland, has issued a leaflet on its "Imperial" commutator stones. Sizes are listed and instructions are given for ordering.

Winton Engine Works of the Winton Co., Cleveland, O., recently issued a handsomely illustrated 22-page booklet describing marine oil installations installed by the company.

Busch-Sulzer Bros. Diesel Engine Co. of St. Louis, Mo., has just issued an 8-page bulletin on the subject of Diesel Engines for Water Pumping Plants. The bulletin contains descriptions of actual installations.

An interesting booklet entitled "Thrift in Lifting" has been issued by Herbert Morris, Inc., of Buffalo, N. Y. This booklet gives practical information in regard to many different lifting problems and describes numerous commercial applications of cranes.

Catalog no. 904, illustrating the Tag Line of instruments, has recently been issued by C. J. Tagliabue Mfg. Co., of Brooklyn, N. Y. This catalog describes briefly, each type of instrument which this company manufactures.

"Heat Losses from Bare Iron Surfaces" is the title of Bulletin 102 issued by the Philips Carey Co., of Cincinnati. The bulletin gives tables and curves by which accurate determinations may be made of the savings to be effected by insulating bare surfaces. These charts and tables should be valuable to every engineer or plant owner who wishes to maintain his plant at the highest efficiency.

An interesting 20-page catalog has recently been issued by the Bernitz Furnace Appliance Co., of Boston, Mass. This catalog describes the Bernitz method of clinker-proof furnace wall construction and is illustrated with a number of photographs which show the application of this construction in actual practice. The Bernitz method of construction makes use of hollow perforated side walls, through which air under slight pressure is supplied to the furnace.

Bulletin No. 3016-S, published by the Hisey-Wolf Machine Co. of Cincinnati, Ohio, describes a new motor driven grinder. This "Wide Swing" grinder as the name implies has the grinding wheels spaced with much more clearance than the regular two wheel grinder. It is especially adapted to the grinding of large bulky castings and many other irregular shaped pieces. It is equipped with a 3 hp. motor and is recommended for two 14 by 2-in. grinding wheels. Buffing and wire brush wheels can also be used with or without wheel guards.

"Treatment of Boiler Feed Water for Highly Overloaded Boilers" is the subject of a pamphlet by David Henderson, of the Dravo-Doyle Co., Pittsburgh, in which he discusses the effect of suspended matter, sodium salts and organic matter in promoting foaming and priming. The lime soda process combined with preliminary heating of the water is able as he points out to secure practically complete precipitation of calcium and magnesium without appreciable excess of reagents. Subsequent filtration through non-siliceous filtering material, which is not soluble in the hot alkaline water, gives a boiler feed supply which will not deposit scale nor form sludge in the boilers, so that they can be operated at the highest ratings with a diminished tendency to priming or foaming and the minimum amount of blowing down. The pamphlet is distributed by H. S. B. W.-Cochrane Corporation, Philadelphia, Pa.